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ATTENTION, ATTACHMENT AND MOTIVATION IN SCHIZOTYPY:
A REVIEW AND EXTENSION OF RESEARCH WITH
THE CONTINUOUS PERFORMANCE TEST

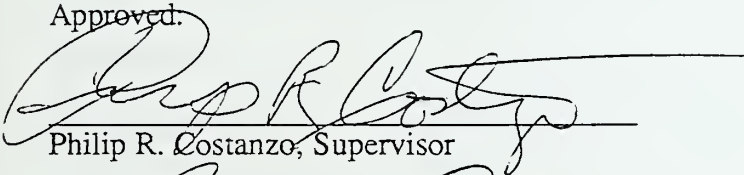
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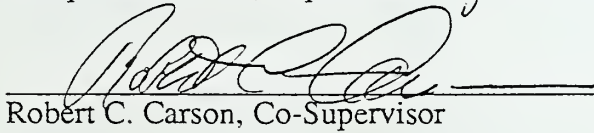
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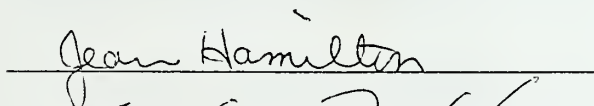
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Dissertation submitted in partial fulfillment of the requirements for
the degree of Doctor of Philosophy in the
Department of Psychology: Social and Health Sciences
in the Graduate School of Duke University

ABSTRACT

(Psychology -- Clinical)

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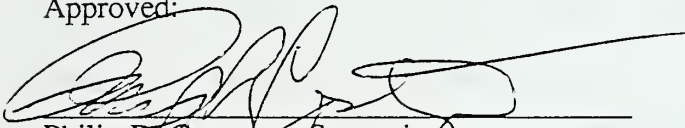
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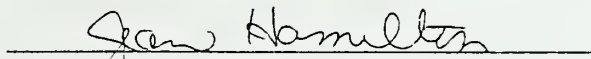
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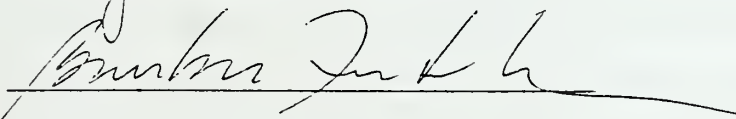
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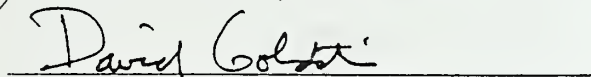
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ABSTRACT

Most contemporary schizophrenia research indicates that a heritable neurointegrative deficit may be a vulnerability marker for schizophrenia spectrum disorders. Researchers often measure this deficit in terms of impaired attention on a vigilance task, the Continuous Performance Test (CPT). Impaired attention is found not only in floridly psychotic schizophrenics, but also in remitted schizophrenics, children biologically at risk for schizophrenia, and young adults psychometrically identified as at risk for schizophrenia spectrum disorders. Findings from these investigations provide a possible link in the diathesis-stress model of schizophrenia genesis. However, little research attention has been paid to the potential interactive effects that attentional impairments and interpersonal relations may have in determining susceptibility to active schizophrenic symptomatology. In this study, 703 undergraduates completed measures of interpersonal attachment, perceived relations with parents and peers in childhood, positive schizotypy (schizophrenism) and negative schizotypy (anhedonia). Based upon their schizotypy scores, 191 of these participants were selected to complete a version of the CPT that, by degrading visual stimuli and presenting them very briefly, rapidly produces decrements in vigilance. In a staggered random design, CPT participants were assigned to one of three motivational induction conditions designed either to increase intrinsic motivation, decrease intrinsic motivation, or to replicate the standard CPT protocol. Path modelling supported a bidirectional relationship between adult attachment and schizophrenia. For female participants, recalled relations with fathers and childhood peers, but not with mothers, predicted adult attachment: for males, recalled relations with mothers, fathers, and childhood peers all predicted adult attachment. Maternal and paternal relations had no direct relationship to schizophrenia, while childhood peer relations and adult attachment were substantially related to schizophrenia for both sexes. Using signal detection indices and growth curve analysis across six blocks of CPT performance, the motivational induction

designed to increase intrinsic motivation was found to attenuate the decrement in vigilance across time, while the motivational induction designed to decrease intrinsic motivation was found to augment the vigilance decrement, compared to the standard CPT protocol. Perceptual sensitivity scores were lower for high schizotypy participants than for low schizotypy participants, such that anhedonic (negative) and schizophrenia (positive) schizotypy interacted to predict the most impaired performance. High schizotypy participants had lowered perceptual sensitivity scores throughout the CPT protocol, but did not show a more rapid decrement in vigilance compared to others. Participants who reported low levels of intrinsic motivation or positive emotion, or who demonstrated diminished persistence in a hand held dynamometer task, also had lowered perceptual sensitivity scores. This relationship was most strong for self-reported intrinsic motivation. Intrinsic motivation was unrelated to schizotypy, and there were no interactions between self-reported intrinsic motivation, schizotypy, and the experimental motivational inductions. High levels of motivation appeared to compensate partially for the impaired attentional performance associated with schizotypy. Contrary to expectations, no interactions between interpersonal attachment and attentional performance were predictive of schizotypal tendencies. Results indicate the importance of the experimental setting as an interpersonal occasion that can either support or undermine attentional performance. The substantial relationship between motivation and attentional performance indicates that future CPT research should include measures of motivation, and that schizophrenia-related deficits in attention may be at least partially eliminated by increasing intrinsic motivation.

ACKNOWLEDGEMENTS

This study was partially funded by a Grant-in-Aid for Research from Sigma Xi, The Scientific Research Society, and by an American Psychological Association Science Directorate Dissertation Award. The Degraded Stimulus Continuous Performance Test software and manual used in this study were made available by Drs. Keith Nuechterlein and Robert Asarnow through the UCLA Clinical Research Center for the Study of Schizophrenia. Great thanks are due to Dr. Nuechterlein for his assistance with this project. Robert Terry patiently provided many hours of invaluable statistical guidance, without which I could not have managed. Members of my dissertation committee provided essential guidance and support throughout the project. Philip R. Costanzo and Robert C. Carson in particular contributed at all stages of my thinking, but most importantly at those formative stages during which basic questions about psychopathology emerged. Credit for the experimental design goes to a suggestion made by Jean Hamilton during my master's defense; her enthusiasm for the current project, including the provision of equipment for over a calendar year, is greatly appreciated. The keen minds of Barb Fredrickson and David Goldstein sharpened my own; their respective interests in emotion and resilience contributed greatly to this study and to the richness of my research experience. Thanks go to Dr. Seymour Epstein for the provision of his Mother-Father-Peer Scale, to Dr. Nancy Collins for provision of the revised Adult Attachment Scale, and to Drs. Edward L. Deci and Richard M. Ryan, who hastened to respond to my eleventh-hour request for their General Causality Orientations Scale and post-experimental Intrinsic Motivation Index in order to meet a Duke University Human Subjects Committee deadline. Although this dissertation research certainly could not have been completed without all of the foregoing help, my deepest gratitude goes to my wife, Julie C. Dunsmore, who has willingly (a) supported this time-intensive research throughout the year and a half it took to complete it, despite the fact that the time was often charged directly to her account, (b) provided

emergency assistance with failing computer hardware and software, (c) tolerated the expensive computer upgrades that ensued, again despite the fact that these costs were charged in part to her account, (d) assisted in the selection of experimental participants, so that I could remain blind to their status on schizotypy and attachment measures, and (d) provided many careful comments on earlier drafts of this manuscript. She is, I think, quite wonderful. She is also, I think, ready for me to be done.

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INTRODUCTION

Research spanning over 25 years has yielded substantial evidence of several types of deficits in attention and perception that appear to be linked to core schizophrenic processes. The nature of these deficits, like schizophrenia itself, is not well understood. Originally attentional disturbances were linked to phenomenological events reported by schizophrenics themselves (Bleuler 1911/1950; J. Chapman 1966; Freedman and Chapman 1973), but more recently these deficits have been conceptualized as representing heritable and/or enduring biological weaknesses that exist before, during and after onset of schizophrenic symptomatology. Attentional deficits are thought to constitute part of the diathesis in the diathesis-stress model of schizophrenia (Nuechterlein and Dawson 1984a; Zupin and Spring 1977). That is, they are thought to be relatively stable vulnerability markers for schizophrenia spectrum disorders (e.g., Asarnow and MacCrimmon 1978; Cornblatt and Erlenmeyer-Kimling 1985; Erlenmeyer-Kimling and Cornblatt 1987, 1992; Erlenmeyer-Kimling, Cornblatt, and Golden 1983; Nuechterlein 1985, 1986, 1991; Nuechterlein and Dawson 1984b; Nuechterlein, Edell, Norris, and Dawson 1986; Nuechterlein, Phipps-Yonas, Driscoll, and Garmezzy 1990; Steinhauer, Zubin, Condray, Shaw, Peters and van Kammen 1991).

Although numerous attention and perception tests have been employed with schizophrenics and schizotypal individuals, one of the most widely used protocols is the Continuous Performance Test (CPT). The CPT requires participants to attend to successively presented visual stimuli and to respond (with a finger lift off a key, a lever pull or a button press) when a predetermined target stimulus appears. Since Rosvold and his colleagues introduced this protocol with brain damaged and other institutionalized participants in 1956 (Rosvold, Mirsky, Sarason, Bransome, and Beck 1956), over 60 CPT studies with schizophrenics, their relatives, offspring, and individuals psychometrically identified to be at risk for schizophrenia spectrum disorders have been reported by

independent laboratories (Appendix A; for reviews see Cornblatt and Keilp 1994; Kornetsky 1972; Nuechterlein and Dawson 1984b; Nuechterlein 1991). Collectively, these studies appear to provide evidence for a decreased capacity for sustained, focused attention in some schizophrenics and individuals at risk for schizophrenia-related disorders.

Concurrent with this line of research, another set of investigators has been studying the "stress" portion of the diathesis-stress model. In particular, investigators have studied deviant patterns of familial dynamics as precursors of schizophrenia spectrum disorders. Contemporary work has its origins in early theoretical and clinical formulations of the etiology of schizophrenia (Fromm-Reichmann 1948; Rosen 1953, 1968; Searles 1959/1986, 1961/1986; Sullivan 1940, 1944, 1953) and in a first wave of research, now abandoned due to methodological flaws (Bateson, Jackson, Haley, and Weakland 1956; Lidz, Cornelison, Terry, and Fleck 1958; Wynne, Ryckoff, Day, and Hirsh 1958). The gist of these early publications was that profoundly disruptive, anxiety-provoking dynamics in the family fostered and reinforced the tangentiality of thought and splitting of associations first described by Bleuler (1911/1950) as characteristic of schizophrenia (for reviews see Carson and Sanislow 1993; Goldstein and Rodnick 1975; Hirsch and Leff 1975; Wynne, Toohey, and Doane 1979). More contemporary prospective work by Goldstein and colleagues (Doane et al. 1982; Doane, West, Goldstein, Rodnick, and Jones 1982; Goldstein 1985, 1990; Valone, Goldstein, and Norton 1984; Valone, Norton, Goldstein, and Doane 1983), by Brown and colleagues (Brown, Birley, and Wing 1972), and by Leff and Vaughn (1985) indicates that parental communication deviance, negative affective style, and high levels of expressed negative and intrusive emotion are predictive of onset and relapse in schizophrenia spectrum disorders.

In the published CPT literature, these two lines of investigation have crossed paths only twice. In both instances parental disturbance has been found to be significantly associated with schizophrenics' CPT performance. Using ratings of maternal

communication deviance with the examiner during a projective test, Wagener, Hogarty, Goldstein, Asarnow, and Browne (1986) found that a subscale of maternal communication deviance, misperceptions and distortions of external reality, accounted for 50% of the variance in CPT performance by schizophrenic offspring. Nuechterlein, Goldstein, Ventura, Dawson, and Doane (1989) found comparable results using a similar design, but in addition to the misperceptions subscale, also found the contorted, peculiar language subscale of parental communication deviance to be significantly related to CPT performance. These data are consistent with a genetic transmission model, in which a common genotype expresses itself in parental communication deviance and offsprings' attentional deviance, with a parent-to-offspring environmental transmission model, in which the impaired perceptual and communicative processes of the parents play a role in the development of attentional disturbance in the offspring (Singer and Wynne 1965a, 1965b; Wynne and Singer 1963a, 1963b), or with an offspring-to-parent environmental transmission model, in which schizophrenia disturbances in the offspring disrupt parental perceptual and communicative processes (Mishler and Waxler 1968; Nuechterlein et al. 1989).

In our recent pilot study, Wilson and Costanzo (1995) found that CPT performance was unrelated to self-reported impairments in attachment, an index of interpersonal disturbance. However, attentional performance interacted significantly with attachment to predict anhedonia, a negative dimension of schizotypy. This interaction indicated that attentional performance was predictive of anhedonia only when attachment was compromised, and that attachment was predictive of anhedonia only when attentional performance was impaired. By way of analogy, we suggested that interpersonal and cognitive processes were intertwined like two strands of a rope, and that when one strand is weakened, the strength of the other predicts the strength of the entire rope, that is, its resistance to psychopathology.

In broad terms, this interaction was consistent with the prevailing diathesis-stress models of schizophrenia (e.g., Nuechterlein 1987; Nuechterlein and Dawson 1984a; Zupin and Spring 1977). When both attentional processes (indexing a neurocognitive vulnerability, the schizophrenia diathesis) and interpersonal attachment processes (indexing psychosocial stress) were impaired, the likelihood of psychopathology increased. More optimal function of either attentional or interpersonal processes served as a buffering factor, while less optimal functioning in either domain served as a risk factor for psychopathology (Garmezy, Masten, and Tellegen 1984; Garmezy 1994).

This dissertation examines interpersonal attachment processes as they relate to schizotypal tendencies in the context of attentional impairments and motivation. The role of attachment processes is critical to consider in developmental psychopathology, particularly when enduring neurointegrative vulnerabilities contribute to the increased likelihood of disorder, as may be the case with schizophrenia spectrum disorders (Meehl 1990). In such cases, attachment relations can have a determinative affect on outcome. Intact attachment may provide motivational and interpersonal connectedness that can buffer individuals from more extreme levels of pathology. This relationship can be illustrated by way of analogy. In the the absence of supporting relationships, age-related deterioration of certain cognitive functions may contribute to geriatric depression and substance abuse. In contrast, the presence of supportive attachment relationships provide meaning and a motivational context that can shield individuals from these types of outcomes. Similar relationships between neurocognitive and interpersonal functioning may well operate in schizophrenia spectrum disorders, as suggested by the diathesis-stress models. Thus, examination of attachment, motivation, and schizophrenic tendencies are crucial to an understanding of the attentional deficits thought to mark these disorders.

Background and Significance

The Continuous Performance Test (CPT) as a Measure of Schizophrenia-Specific Attentional Impairment

Although multiple studies have indicated that the CPT appears to tap attentional processes which are relatively specific to and predictive of schizophrenia spectrum disorders, the literature is quite complex. Indeed, three sets of issues make unqualified conclusions about CPT schizophrenia research untenable.

1. The diversity of schizophrenic disorders. Schizophrenia represents a collection of heterogeneous subsets of disturbance, each perhaps possessed of its own unique etiological pathway (Bellak 1979, 1994; Carson and Sanislow 1993; Chapman and Chapman 1989a; Nuechterlein 1991; Nuechterlein and Dawson 1984a, 1984b; Zahn, Carpenter, and McGlashan 1981a, 1981b). Studies that gather these subgroups under the single diagnostic category of schizophrenia therefore may inadvertently introduce sampling confounds. For example, most studies find that only about 40% of the schizophrenics tested perform poorly on the CPT; the CPT performance of the remainder is indistinguishable from that of normal controls (Kornetsky and Orzack 1978; Orzack and Kornetsky 1966, 1971; Wagener et al. 1986; Walker and Shaye 1982). The group of biologically at-risk children is characterized by even lower percentages of members exhibiting poor CPT performance; somewhat less than 30% of children born to schizophrenic mothers show poor performance on the protocol (Erlenmeyer-Kimling and Cornblatt 1992; Nuechterlein 1983, 1985; Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1986). Similar proportions have been consistently reported by Erlenmeyer-Kimling and Cornblatt using an attentional index composed of multiple scores from CPT and other attentional tests (Erlenmeyer-Kimling and Cornblatt 1978; Cornblatt and Erlenmeyer-Kimling 1985; Cornblatt and Marcuse 1986; Cornblatt, Winters, and Erlenmeyer-Kimling 1989). However, using a taxometric approach that included CPT,

neuromotor, Bender-Gestalt and intelligence scores, these investigators found a higher rate of deviancy among at-risk children, as indexed by taxon membership, ranging from 39% to 47% (Erlenmeyer-Kimling, Golden, and Cornblatt 1989). Thus optimal methods for identifying subgroups, both within schizophrenics and within children at risk for schizophrenia, have yet to be agreed upon.

Compounded with these difficulties are changes in the official diagnostic criteria for schizophrenia, requiring in cases of longitudinal research the reclassification of participants (e.g., Erlenmeyer-Kimling et al. 1983). The exclusion of affective symptomatology from schizophrenia diagnostic criteria in the DSMIII and DSMIII-R renders comparison of pre-1980 studies with more contemporary research problematic, because it is likely that different populations were studied in the two eras (Carson and Sanislow 1993). Moreover, although these recent criteria are more stringent and therefore more reliable, their clinical validity has not yet been adequately demonstrated (Erlenmeyer-Kimling et al. 1989). Thorough discussion of these issues is beyond the scope of this project, and for present purposes it is sufficient to note that the nature of core processes involved in the schizophrenias remains open to considerable debate (e.g., Bentall 1990/1992; Flack, Miller, and Weiner 1991).

2. The diversity of CPT protocols. As Nuechterlein (1991) highlights, over the years several different types of CPT protocols have been developed, making across-study comparisons hazardous. The variety of equipment used to conduct CPT protocols include the original rolling drum with a window through which the rotating target stimuli were viewed (e.g., Cohler, Grunebaum, Weiss, Gamer, and Gallant 1977; Grunebaum, Cohler, Kauffman, and Gallant 1978; Rosvold et al. 1956), slides projected onto a rear view screen by means of a carousel (e.g., Asarnow and MacCrimmon 1978; Nuechterlein 1983; Rutschmann et al. 1977) and, more recently, tachistoscopic presentation of stimuli on computer monitors (e.g., Buchsbaum and Sostek 1980; Walker 1981; Serper, Bergman,

and Harvey 1990). A variety of modifications to the task parameters of the CPT have also been made, including variations in the nature of target stimuli, the presence or absence of same or cross-modal distraction, the rate and duration of stimulus presentation, the percentage of presented stimuli that are designated as targets, the overall duration of the CPT, and the presence or absence of reinforcement. Modifications to the CPT took place largely in an effort to make the task sufficiently demanding to discriminate between at-risk and normal individuals (Cornblatt and Erlenmeyer-Kimling 1984; Cornblatt, Risch, Faris, Freidman, and Erlenmeyer-Kimling 1988; Erlenmeyer-Kimling, and Cornblatt 1992; Nuechterlein and Dawson 1984a; Nuechterlein 1984a, 1985, 1991). In the single study that investigated performance under six different CPT protocols, performance varied across the six protocols (Nuechterlein 1983; Nuechterlein et al. 1990, Table 20.4). Because systematic examination of these parameter changes has not been conducted, each type of parameter modification is briefly reviewed below. A chronology of CPT research showing many of these parameter changes is presented in Appendix A.

3. The problem of CPT measurements. It is not always clear what the CPT measures. There is some evidence that CPT deficits may involve heightened susceptibility to distraction and poor ability to maintain attentional set without interruption. However, there is also evidence that CPT performance is closely related to motoric skill, and to impaired perceptual extraction and decoding abilities. *What* the CPT measures is also tied up with *how* CPT performance is measured. Most contemporary studies now employ signal detection indices to separate response style (usually derived as $\ln \beta$) from perceptual sensitivity (usually derived as d'). $\ln \beta$ is a measurement of how conservative or liberal a subject is in responding to stimuli; it is an index of how much perceptual evidence of a target must be present before the individual responds. Low $\ln \beta$ scores correspond to a liberal response style, while high $\ln \beta$ scores correspond to a conservative response style and may indicate lack of motivation or disengagement with the protocol.

Although response bias has received considerable attention in the vigilance literature, it is the discriminability index d' that is usually the measurement of interest in schizophrenia research. This index represents the distance between signal (target) and noise probability density distributions in standard deviation units, so that a d' of 0 indicates that target-noise discrimination is at a chance level, and a d' of 1 indicates perfect ability to distinguish signals from noise (Davies and Parasuraman 1982; Macmillan and Creelman 1991). Provided that the underlying assumptions required by signal detection theory can be met in the CPT protocol, the use of these sophisticated measures in contemporary work provide a clear distinction between response style and actual perceptual sensitivity.¹ In contrast, early CPT studies usually simply measured errors of omission and commission, from which d' and $\ln \beta$ can be derived. The poor performance reported for schizophrenics in early studies therefore may have arisen from a disengaged response style, poor signal-noise discrimination, or both.

To elucidate the complexity of CPT research and measurement, a detailed review of the diverse CPT protocols is presented first, followed by consideration of the related measurement issues.

Review of CPT Protocols

Variations in target stimuli. In early studies, a simple version of the CPT was employed that required participants to pull a lever or press a lever every time a single target stimulus, the letter "X," appeared (Grunebaum et al. 1978; Grunebaum, Weiss, Gallant,

¹ The two assumptions required by classical signal detection theory are that the distributions of perceptual evidence for target and non-target trials are approximately normal and homoscedastic. I am unaware of any CPT studies that have tested these assumptions, thus bringing into some doubt the introduction of these parametric indices to CPT research. As noted below and recommended by Nuechterlein (1991), nonparametric signal detection indices are more appropriate when these underlying assumptions cannot be tested. Although nonparametric signal detection indices are well-established (Aaronson and Watts 1987; Grier 1971), they are only just beginning to be used in CPT research (see Appendix A). In fact, parametric and nonparametric indices show very high correlations ($r > .9$) so long as deviations from signal detection assumptions are small (Nuechterlein 1991); however, the crucial step of assessing signal and noise distributions should be made before relying on parametric measures.

and Cohler 1974; Kornetsky and Orzack, 1964; Latz and Orzack 1965; Orzack and Kornetsky 1966; Spohn, Lacoursiere, Thompson, and Coyne 1977). Frequently single numbers rather than letters were employed as stimuli (Asarnow and MacCrimmon 1978; Asarnow, Steffy, MacCrimmon, and Cleghorn 1977; Nuechterlein, 1983; Orzack, Kornetsky, and Freeman 1967). A more recent variant uses a simple geometric form such a circle with a dot above it as the designated target (Erickson, Yellin, Hopwood, Realmuto, and Greenberg 1984).

In the same report that introduced the simple X version of CPT, Rosvold and his colleagues also introduced an "A-X" version of the CPT that required participants to respond to the target "X" only when it was immediately preceded by an "A" (Rosvold et al. 1956). This version increased the processing load demanded by the protocol by involving a higher short-term memory load in participants' signal detection and response processes, and has subsequently been used in numerous studies, either in numeral or alphabetic form (Buchsbaum, Murphy, Coursey, Lake, and Ziegler 1978; Nuechterlein et al. 1986; Serper et al. 1990; Wagener et al. 1986; Walker 1981; Walker and Green 1982; Walker and Shaye 1982; Wohlberg and Kornetsky 1973). Although these studies have been largely be able to differentiate schizophrenic from control group participants, both the X and the A-X CPT protocols failed to detect attentional deficits in at-risk children compared to control children (Asarnow et al. 1977; Cohler et al. 1977; Cornblatt and Erlenmeyer-Kimling 1984; Grunebaum et al. 1978; Herman, Mirsky, Ricks, and Gallant 1977; Nuechterlein 1983), and there have been occasional reports of failure to find attentional deficits in schizophrenics with these conventional forms of the CPT (Erickson et al. 1984; Wagner, Kurtz, and Engel 1989).

Provocatively, an early study by Grunebaum et al. (1974) found attentional deficits in five-year-old genetically at-risk participants using the color red as a target in a CPT protocol, but not in six-year-old at risk participants using the X version of the CPT. A

follow-up report on a subset of these participants three years later indicated that high-risk participants remained indistinguishable from controls on CPT *performance*, although high-risk participants' visual evoked potentials during the CPT had markedly increased latencies and amplitudes compared to controls, suggesting a subtle developmental lag in visual stimulus processing (Herman et al. 1977). These studies raised the problem of identifying developmentally appropriate attentional tasks and gave momentum to the search for more demanding versions of the CPT (Nuechterlein 1984a; Nuechterlein and Dawson 1984a).

Shortly after the introduction of the X and A-X versions of the CPT, Rutschmann, Cornblatt, and Erlenmeyer-Kimling (1977; Erlenmeyer-Kimling and Cornblatt 1978) reported on an identical-pair playing card version of the CPT, which required participants to respond only when two identical cards appeared successively on a projection screen. The playing card version made processing load demands higher still, because it required participants to process stimuli along two dimensions (card suit and number) and also involved the short-term memory processes that were required by the A-X CPT. The playing card CPT has successfully distinguished at-risk from normal children (Cornblatt and Erlenmeyer-Kimling 1985; Erlenmeyer-Kimling and Cornblatt 1978; Rutschmann et al. 1978). Follow-up research indicated that early assessments of high risk children's CPT performance were predictive of clinical psychopathology at age 17.5 (Erlenmeyer-Kimling and Cornblatt 1992).

In 1986 this research group reported on a computerized double digit version of the CPT in which the target was either a "08" (analogous to the X CPT) or identical pairs of "17" (roughly analogous to the A-X CPT). The simpler 08 version failed to distinguish at-risk from normal children, whereas the more demanding identical pairs double digit CPT succeeded (Rutschmann et al. 1986). Importantly, these investigators also reported that CPT performance in both tasks, as measured by factor scores for discriminability, showed a linear age progression, with older participants doing better (Rutschmann et al. 1986, n.

6). Like the playing card CPT, the identical pairs double digit CPT is predictive of adolescent psychopathology (Erlenmeyer-Kimling and Cornblatt 1992).

Most recently Cornblatt and Erlenmeyer-Kimling have developed a high-processing load identical pairs CPT using numeric and nonsense shape stimuli (Cornblatt et al. 1988; Cornblatt, Lenzenweger, and Erlenmeyer-Kimling 1989). This version of the CPT appears to be immune to ceiling effects, distinguishes the performance of high risk offspring from that of normal controls, and is sensitive to the presence of psychometrically identified schizotypy in otherwise normally functioning college students (Lenzenweger, Cornblatt, and Putnick 1991; Winters, Cornblatt, and Erlenmeyer-Kimling 1991). Findings of age-related changes in performance, dependent on the type of target stimulus, persist in this version of the CPT protocol: normal adolescents out-performed their parents when the target stimuli were nonsense shapes, but not when the target stimuli were numbers (Cornblatt et al. 1988).

Harvey and his colleagues (Earle-Boyer, Serper, Davidson, and Harvey 1991) have recently tested the effect of target familiarity on CPT performance using both visual and auditory modalities. Relative to medicated schizophrenics and normal controls, unmedicated schizophrenics made more errors of commission and omission when the target was a predesignated pair of 3-letter nonsense syllables (e.g., "gok" followed by "sij"), but not when the target was a predesignated pair of 3-letter words (e.g., "day" followed by "far"). Earle-Boyer et al. suggest that medication effects may play an important interactive role with stimulus type in effecting CPT performance (see also Harvey et al. 1990).

The versions of the CPT just reviewed increased the complexity of the CPT protocol primarily by increasing the demand on higher-order cognitive processes such as short-term memory, conceptual matching, and simultaneous processing of stimuli along more than one physical dimension. In 1983 Nuechterlein introduced a degraded stimulus version of the CPT, or DS-CPT (Nuechterlein 1983; Nuechterlein et al. 1983). Instead of

increasing *cognitive* demand loads at higher order levels, the DS-CPT increased *perceptual* demand loads by making the target stimuli more difficult to distinguish. This protocol had an immediate practical advantage over other CPT versions in that it produced a rapid decrement in perceptual sensitivity within five minutes (Nuechterlein et al. 1983), rather than requiring lengthy CPT trials during which a decline in motivation could be expected to appear. Moreover, because the DS-CPT does not obviously involve a high degree of memory or other higher order cognitive processes, it may be a more precise measure of the stimulus encoding and feature extraction processes that comprise immediate attentional processes (Nuechterlein 1984a; Nuechterlein and Dawson 1984a). It is this version of the CPT that was employed in the current study.

The DS-CPT appears to be immune to practice effects (Nuechterlein et al. 1983) and has good discriminating power for at-risk children (Nuechterlein 1983; Nuechterlein, Garmezy, and Devine 1989), young adults psychometrically identified as at risk for schizophrenia spectrum disorders (Nuechterlein 1985), and schizophrenics (Nuechterlein et al. 1986). Test-retest correlations ranging from .74 to .84 show that chronic schizophrenics' DS-CPT performance remains reasonably stable over periods up to one year (Nuechterlein 1985). Impaired performance on the DS-CPT in schizophrenics has been shown to be significantly correlated with (a) impaired recognition of components essential to social cognition (Corrigan, Wallace, and Green 1982), (b) negative schizophrenic symptomatology, including the Brief Psychiatric Rating Scale Anergia factor subscales of emotional withdrawal, motor retardation and blunted affect, and (c) Rorschach-assessed thought disorder (Nuechterlein et al. 1986).

Variations in distraction-no distraction conditions. In addition to increasing the complexity of the target and non-target stimuli in the CPT, many researchers have added distraction conditions to increase the overall difficulty of the CPT protocol. Using the A-X CPT, Wohlberg and Kornetsky (1973; Kornetsky 1972) found that remitted, non-

medicated schizophrenics performed more poorly under a condition simultaneously employing both visual (strobe light flashes) and auditory (metronome beats) distractors, both when compared to performance under non-distraction conditions, and when compared to control participants. Asarnow and MacCrimmon (1978) replicated these findings with medicated remitted schizophrenics using an X version of the CPT and an auditory distraction condition (digits read in random order through headphones). Using the A-X CPT, Walker (1981) found that the presence of auditory distraction facilitated CPT performance for patients with affective disorders and for schizoaffectives, but not for schizophrenics. Taken together, these early studies suggested that distractibility in CPT performance was specific to schizophrenia. The picture rapidly became more complex, however.

First, although Grunebaum et al. (1978) found results for schizophrenic adults that were comparable to these early distraction CPT studies, similar results were not found for at-risk children, whose performance on an X version of the CPT did not differ in the presence of auditory distraction. Cornblatt and Erlenmeyer-Kimling and their colleagues also employed auditory distraction (a random series of numbers spoken into headphones) with their playing card CPT and found that distraction had about equally deleterious effects for both high-risk and control children (Cornblatt and Erlenmeyer-Kimling 1985; Erlenmeyer-Kimling and Cornblatt 1978; Rutschmann et al. 1977). In their more recent identical pairs version of the CPT, Cornblatt, Erlenmeyer-Kimling and their colleagues have found that the presence of auditory or visual distraction *improves* CPT performance in non-psychiatric controls, but not in schizophrenic or depressed patients (Cornblatt et al. 1989; Cornblatt et al. 1988). Consistent with their earlier findings that high-risk children were not differentially affected by the presence of distraction, Cornblatt, Erlenmeyer-Kimling and colleagues concluded that distractibility is not specific to schizophrenia but is instead a general correlate of psychiatric illness (Cornblatt et al. 1989). This conclusion is

at odds with Walker's (1981) findings of a schizophrenic-specific impairment in distraction noted above, so additional research is required before a clear picture can emerge.

Three other findings are pertinent here. First, Walker and Shaye (1982) found a trend toward greater A-X CPT deficits under an auditory distraction condition when schizophrenic patients had nuclear family histories positive for schizophrenia, whereas no such trend was found for schizophrenics without positive family histories. Second, using the same A-X CPT with auditory distraction, Walker and Green (1982) found that distraction was most disruptive for schizophrenic patients with poor motor skills. Third, Cornblatt et al. (1988) found that normal adolescents' performance on the identical pairs CPT improved more under distraction conditions than did the performance of their parents. Although caution is warranted in generalizing from these diverse studies, it appears that the introduction of distraction conditions in CPT protocol has age-specific effects that probably interact with prior neuromotor and genetic loading status. Differential effects of distraction on CPT performance depending on the type of target stimuli used also cannot be ruled out.

Variations in rate and duration of stimuli presentation. A cursory inspection of Appendix A reveals that the rate and duration of stimuli presentation have varied significantly over the course of CPT research. These variations are important determinants of participants' performance, but the effect of rate and duration of target stimuli has not been systematically studied with schizophrenics or high risk participants. The interval between CPT stimuli (interstimulus interval, or ISI) has generally been set at about 1 second, but considerable variation in ISI setting exists. Recent studies using positron emission tomography to measure brain glucose metabolism in schizophrenics engaged in a CPT increased the ISI to almost 2 seconds (Buchsbaum et al. 1990; Guich et al. 1989; Hazlett, Dawson, Buchsbaum, and Nuechterlein 1993), as did a CPT study with adolescent schizophrenics (Erickson et al. 1984), and an EEG study of acute

schizophrenics engaged in a CPT used ISIs randomly varying between 1.5 and 3 seconds (Wagner et al. 1989).

In contrast, Buchsbaum and colleagues have increased task difficulty by shortening the ISI to an initial period of 400 msec, and then allowing the ISI to be driven by the subject's performance, such that correct responses produced a decrease in the subsequent ISI by 5%, while errors produced a 5% increase in the subsequent ISI (Buchsbaum et al. 1978; Buchsbaum and Sostek 1980; Huhtaniemi, Haier, Fedio, and Buchsbaum 1983). In this dynamic CPT, the ISI then becomes a potentially important index of individual participants' optimal performance rates. Unfortunately, no studies employing this protocol with schizophrenics have been published, and in the single report in which ISI was analyzed, there was no significant difference in the ISI measure between biochemically at risk (low platelet monoamine oxidase) and control participants (Buchsbaum et al. 1978). It is generally thought, however, that shorter ISIs increase the task difficulty (Chee, Logan, Schachar, Lidsay, and Wachsmuth 1989), decrease average detection rate (Davies and Parasuraman 1982), and produce a decrement in d' over time (Davies and Parasuraman 1982; Parasuraman 1979; Swets and Kristofferson 1970).

In Wagner et al.'s (1989) study, in a condition with a variable ISI randomly fluctuating between 1.5 and 3 seconds, both schizophrenics and normal control participants slowed their reaction times relative to their performance under an invariant ISI, but performance was not otherwise altered. Longer ISIs may permit impulsive responders more time to inhibit their incorrect responses (Sykes, Douglas, Weiss, and Minde 1971), but ISIs that are too long may reduce schizophrenics' ability to maintain optimal levels of readiness to respond, or what Rodnick and Shakow (1940) termed "set" in their reaction time cross-over study (see also Chee et al. 1989; Nuechterlein, 1977; Spring, Lemon, and Fergusson 1990).

Duration of stimuli presentation has varied with study and type of target stimuli, ranging from 600 msec for Erlenmeyer-Kimling and Cornblatt's identical pairs playing card CPT (Rutschmann et al. 1977; Erlenmeyer-Kimling and Cornblatt 1978) and 500 msec for Earle-Boyer et al.'s (1991) 3-letter target CPT, down to 40 msec for Nuechterlein's DS-CPT (Nuechterlein 1983; Nuechterlein et al. 1983). At least at the very fast end of the presentation spectrum, changes of as little as 10 msec make a difference; Nuechterlein has found that while the DS-CPT is appropriate for elementary school aged children with a stimulus duration of 50 msec, this was too easy for junior high school aged children; 40 msec stimulus durations eliminated ceiling effects among these older participants (Nuechterlein, 1984a; Nuechterlein et al., 1983). Decreasing the stimulus duration thus appears to increase task difficulty and keep pace with developmental increases in CPT performance.

However, it should also be pointed out that the effect of shortening the stimulus presentation is to decrease the amount of time during which stimulus encoding and feature extraction take place, and these components of attention have recently been found to slow at the rate of 4 to 10 msec per year over the normal life course (Madden 1992). By implication, a 40 msec stimulus presentation may be differentially more difficult for many of the older participants who typically make up chronic schizophrenic samples. It is therefore reasonable to hypothesize that interactions among age, ISI, stimulus type and duration of stimulus presentation have a marked effect on CPT performance. This hypothesis is supported by findings of an interaction between ISI and stimulus type in research with hyperactive children (Sykes et al. 1971).

Variations in prevalence of target stimuli. Like stimulus duration and rate of presentation, the relative prevalence of the target stimuli in a given block of CPT stimuli presentations has varied considerably over the course of CPT research. The relative prevalence of the target can be examined in two ways: first, in terms of percentage of

presented stimuli that are designated as targets (presentation prevalence rate, shown in Appendix A), and second, in terms of the number of different non-target stimuli that must be processed and eliminated before a decision to inhibit a response can be made. For example, in the original research conducted by Kornetsky, Orzack and their colleagues (Kornetsky and Orzack 1964; Latz and Kornetsky 1966; Orzack and Kornetsky 1966), the critical stimulus X appeared on average once every 5 trials (a presentation prevalence rate of 20%) and was one of 12 possible stimuli. When they modified the CPT using the digit 0 as the critical stimulus, the presentation prevalence rate remained at an average of 20%, but the digit 0 became one of only 10 possible stimuli (Orzack and Kornetsky 1971; Orzack et al. 1967). In Rutschmann et al.'s (1977) playing card CPT, the target pair of stimuli appeared at an average rate of 12.5%, there were 18 possible stimuli, and a much larger number of possible pairs. In Nuechterlein's DS-CPT, the degraded digit 0 appears on an average of 25% of the trials and is one of 10 possible stimuli (Nuechterlein 1983; Nuechterlein et al. 1983). Presentation prevalence rates of up to 30% (Herman et al. 1977) or as little as 10% or 11% (Buchsbaum et al. 1980; Strauss et al. 1986) have been used with X, A-X and higher memory load versions of the CPT.

Again, the effects of these variations in the CPT protocol have not been studied systematically with schizophrenics. However, it is believed that increasing the presentation prevalence rate of the target will increase participants' tendency to respond to non-target stimuli, because the probability that a given stimulus is a target is high (Nuechterlein 1983). Low target rates produce more conservative response criteria in normal participants (Davies and Parasuraman 1982; Swets and Kristofferson 1970). Increasing the target-to-non-target ratio also produces linear increases in d' in normal participants (Davies and Parasuraman 1982; Swets and Kristofferson 1970). The effect of altering the number of different types of non-target stimuli in the presentation sequence has not been examined. However, if many different non-target stimuli are possible (e.g., 24 letters rather than just 12 or even 4,

as in Wagner et al.'s (1986) study), then task difficulty may be raised by requiring additional processing of non-targets.

Variations in task duration. Finally, CPT protocols have been as brief as 4 or 5 minutes (Kornetsky and Orzack 1964; Orzack and Kornetsky 1966, 1971) and as long as half an hour (Asarnow and MacCrimmon 1978; Buchsbaum et al. 1990), with the majority of protocols falling in between. However, in one exceptional study involving intensive training with schizophrenics, the CPT lasted about 1 hour 25 minutes (Serper et al. 1990). The effect of task duration on performance, or decrement of perceptual sensitivity over time, is a classic index of vigilance (Davies and Parasuraman 1982; Swets and Kristofferson 1970). Presumably, all other factors being equal, the longer the task duration, the greater the decrement in d' , and the lower the d' value averaged over the course of the task will be.

However, sensitivity decrement has very rarely been measured in the studies considered here (Cornblatt and Keilp 1994; Nuechterlein 1991), and the results are mixed. Using the DS-CPT, Nuechterlein and others have found rapid decrements in perceptual sensitivity over a period of 5 to 8 minutes (Nuechterlein et al. 1983; Strauss, Brandt, and McSorely 1986), but these decrements were equivalent for children at high risk for schizophrenia and for age-matched controls (Nuechterlein 1983). A similar vigilance decrement has been found with schizophrenics, but absence of a control group precludes comparison of this decrement with that of normal participants (Nuechterlein et al. 1986). Mussgay and Hertwig (1990) found a significant decrement in perceptual sensitivity over time for schizophrenics but not for controls; unfortunately, these results were obscure because time effects were apparently confounded with changes in task difficulty, and response bias was found to be significantly correlated with perceptual sensitivity. Although Corrigan et al. (1992) apparently measured schizophrenics' and control

participants' sensitivity decrements with the DS-CPT, only schizophrenics' decrement score was reported, again prohibiting an appropriate comparison.

The best evidence for a more rapid decline in perceptual sensitivity associated with schizophrenia is provided in two studies conducted by Nestor and colleagues using a version of the DS-CPT (Nestor, Faux, McCarley, Sands, Horvath, and Peterson [1991]; Nestor, Faux, McCarley, Shenton, and Sands [1990]). In their first report, Nestor et al. (1990) found that schizophrenics with positive or mixed-symptom profiles both had lower perceptual sensitivity throughout the CPT protocol, and declined more rapidly in perceptual sensitivity as time elapsed, compared to normal controls. Their second investigation (Nestor et al. 1991) did not include normal controls, but instead compared the performance of medicated schizophrenics to schizophrenics recently withdrawn from neuroleptics. Medicated schizophrenics showed no decrement in perceptual sensitivity, while schizophrenics withdrawn from medication showed a pronounced vigilance decrement (Nestor et al. 1991, Figure 1). Regrettably, the use of just three time points to assess the drop in perceptual sensitivity in each study compromises the level of confidence to be placed in these findings; a greater number of repeated measures would have provided a better estimate of the differential rates of decline for the groups of participants.

Vigilance decrements are not always present in CPT protocols. Using a high memory load CPT that was matched for discriminating power with the DS-CPT, Strauss et al. (1986) found that paid volunteers' sensitivity actually increased over trials. In a recent study of schizophrenics, depressed patients and normal controls using an identical pairs CPT, no decrements in perceptual sensitivity over time were found for any of the groups (Cornblatt et al. 1989). Instead, the only significant finding for task duration was that all participants became increasingly conservative in responding with time, a common finding in vigilance research (Davies and Parasuraman 1982; Swets and Kristofferson 1970). Nuechterlein (1991) has suggested that there is currently no evidence of a differential drop

in perceptual sensitivity for at-risk or schizophrenic participants, although it is possible that a subgroup of schizophrenics may exhibit a steeper vigilance decrement. Thus, although the length of CPT protocols has varied greatly, measurement of sensitivity decrement over these varying task durations has generally not been adequately reported, so that very little is known about the effect of task time on CPT performance.

As underscored by these mixed findings and by an earlier review by Nuechterlein (1991), systematic variation of CPT task parameters remains to be studied. As the literature now stands, it is possible neither to sort out the important experimental variables that impact CPT performance nor to compare studies directly. To this is added the difficult task of delineating the cognitive processes tapped by the CPT.

Measurement Issues Related to CPT Protocols

Theoretical considerations. The CPT was originally conceived of as a test of continuous attention, or vigilance (Rosvold et al. 1956). The preponderance of studies listed in Appendix A, with schizophrenics (acute, chronic and remitted), children at risk for schizophrenia, and psychometrically at risk college students, indicates that a portion of these groups perform significantly less well than normal controls on the CPT, provided that the version of the CPT employed is sufficiently demanding (see Nuechterlein, 1991; Nuechterlein and Dawson, 1984b). However, it is not entirely correct to conclude that these subgroups of schizophrenics and at-risk participants therefore exhibit a deficit in sustained attention. As discussed above, evidence for a vigilance deficit per se is weak, due to the lack of empirical measurement of vigilance decrement over time. But if sustained attention is not being measured by the CPT, what is?

CPT performance deficits were originally attributed to overarousal of the ascending reticular activating system in the brain stem. This overarousal was characterized by poor filtering, or a lowered threshold for input, and resulted in ongoing attention being continually interrupted by competing stimuli (Kornetsky and Mirsky 1966; Orzack and

Kornetsky 1966; Orzack et al. 1967). After this hypothesis, most investigators up until the mid-1980's simply referred to schizophrenics' lowered CPT performance as indicative of "attentional deficit," even while acknowledging the ambiguity of this term (e.g., Asarnow et al. 1977). In 1984 Nuechterlein and Dawson (1984a, 1984b) theorized that attentional deficit in schizophrenia was due to a reduction in available cognitive processing capacity. They suggested that this reduction might result from either (a) poor allocation of available processing capacity, (b) increased allocation of processing capacity to irrelevant or internal stimuli, (c) increased allocation of processing capacity to cognitive operations that are normally automatic but which have ceased to be so, or (d) a decrease in the total pool of processing capacity. About this time Gjerde (1983) suggested a synthesis of the hyperarousal and hypocapacity theories by arguing that reduced processing capacity in schizophrenia resulted from overarousal. Related models, such as the proposal that schizophrenics suffer from an inability to inhibit irrelevant stimuli, have been offered by many others (e.g., Beech, McManus, Baylis, Tipper, and Agar 1991; Carr and Wale 1986; Everett, LaPlante, and Thomas 1989; Frith 1979; Saccuzzo 1986; Venables 1984). Most recently, brain glucose and brain wave studies with schizophrenics engaged in the DS-CPT indicate that impaired processing capacity may be related to weak neurocortical pathways in the right hemisphere that connect the prefrontal cortex to the right temporal and sensory cortices (see Nuechterlein, Buchsbaum, and Dawson [1994] for a review).

The reduced processing capacity model led Erlenmeyer-Kimling and Cornblatt (1985) to approach the problem of attentional deficit in at risk children from a global perspective. They suggest that the attentional dysfunctions involved in the pathogenesis of schizophrenia are multiple and complex, and that attempts to establish a single attentional process as a marker for schizophrenia in high risk research are unlikely to prove fruitful (Cornblatt and Erlenmeyer-Kimling 1985). Consistent with this approach, the majority of their findings are reported in terms of the attentional deviance index noted previously,

composed of multiple scores from several different tasks that demand a high degree of effortful, momentary processing. Although this approach has been productive in their longitudinal work, a global, composite-measurement approach to the problem of attention in schizophrenia does not permit identification and disentanglement of the specific cognitive processes that may be involved in poor CPT performance.

If poor CPT performance can be included in a composite measurement of global attention deficit, then CPT scores should correlate with other measures of attention. However, a traditional difficulty with the CPT as a measure of attention is that it is generally found to be uncorrelated with other protocols that are also intended to measure similar aspects of attention (Asarnow and MacCrimmon 1978; Benedict et al. 1994; Böker et al. 1989; Wagener et al. 1986). Kopfstein and Neale's (1972) study of attention in schizophrenics and other psychiatric patients using an auditory vigilance task similar to the visual CPT found no significant correlations between vigilance and performance on the other attentional tasks. Along the same lines, Asarnow et al. (1977, 1978) employed cluster analysis to identify an attentionally deviant subgroup of their high risk sample of children. The clusters were formed using a variety of attentional and cognitive measures as clustering variables, including those derived from the X CPT. With the exception of a single high risk child (who was highly deviant on all tasks and assigned to a separate cluster), the participants who were assigned to the most attentionally deviant cluster had *perfect* CPT scores. Most recently, however, DS-CPT perceptual sensitivity scores have been found to correlate strongly with other measures of target detection and distractibility (Bowen et al. 1994). To my knowledge, this is the only study to report such positive correlations, and the reasons for these disparate findings are not yet clear.

The CPT therefore appears to be measuring some unique component or components of attentional, perceptual and/or motoric processes that are not tapped to a significant degree by other tests of attention. With respect to attentional and perceptual processes,

Nuechterlein (1991) has most recently hypothesized that the schizophrenia-related deficit in CPT performance is due either to (a) sporadic, transient interference in sustained attention (rather than the traditional index of vigilance decrement, a progressive drop of d' over time), or (b) a difficulty in rapid visual processing of each successively presented stimulus. Nuechterlein (1991) suggests that the sporadic interference explanation of impaired CPT performance may also underlie the robust findings of jagged, irregular smooth pursuit eye movements in a subset of schizophrenics, their relatives, their offspring, and individuals high in schizotypy (Holzman, 1990; Holzman et al., 1974; Holzman, Levy and Proctor, 1976; Lencz et al., 1993; Shagass, Roemer and Amadeo, 1976; Siever et al., 1990), while the impaired rapid visual processing explanation can be linked to other findings of slowed visual processing in schizophrenia (Knight, Elliot, and Freedman 1985; Nuechterlein and Dawson 1984b; Saccuzzo 1986; Schuck and Lee 1989). Both explanations are broadly consistent with the decreased available processing capacity model (Nuechterlein 1991). However, two additional sets of findings need to be considered.

Neuromotor performance and the CPT. First, given the demands of the task, it is not surprising that CPT performance often appears to be linked, either directly or indirectly, to neuromotor performance. Nuechterlein has reported a correlation of $-.39$, $p < .01$, between CPT d' and reaction time factor scores in at risk children (Nuechterlein 1985) and a correlation of $-.45$, $p < .01$, between DS-CPT d' scores and ratings of motor retardation in schizophrenics (Nuechterlein et al. 1986). Buchsbaum et al. (1985) reported associations between impaired neuromotor performance, increased reaction times in an auditory task, and poor performance on a dynamic A-X CPT, but no evidence of any link to schizophrenia-related disorders was found. In an early path analysis, Erlenmeyer-Kimling et al. (1982) found a path coefficient of $.65$ from neuromotor to attentional functioning (see also Erlenmeyer-Kimling and Cornblatt 1992). These findings are important, because motoric response demands of various CPT protocols have varied from a

lever pull (e.g., Kornetsky and Orzack 1964) to a button push (e.g., Rutschmann et al. 1977) to a finger lift from a button (e.g., Cornblatt et al. 1988), each of which may differ in the neuromotor skills involved.

Perhaps the most compelling evidence of neuromotor involvement in the CPT is provided by Walker and Green (1982), who found strong negative correlations between motoric skill scores and omission errors on a distraction-no distraction version A-X CPT. These correlations ranged as high as $-.76$, $p < .05$, for a measure of eye-hand coordination that involved reproducing geometric forms, drawing lines and cutting out circles. Thus, the likelihood of responding to target stimuli on the CPT appears to depend greatly on motoric skill. Partialling out variance from conditions with no distraction so as to isolate the effects of distraction on CPT performance, Walker and Green (1982) also found that distraction was most deleterious for schizophrenics with poor motor skills. In discussing these results, Walker and Green (1982) and Nuechterlein (1991) suggest that the CPT could be detecting attentional impairments resulting from a basic neurointegrative defect that produces both motoric and attentional impairments. This interpretation can be tied to a large body of research and theory which suggests that a neurointegrative defect is a core vulnerability factor for schizophrenia (e.g., Cantor 1988; Erlenmeyer-Kimling et al. 1982; Fish 1977; Meehl 1962, 1989, 1990; Walker and Lewine 1990).

Anhedonia and the CPT. In addition to these neuromotor findings, a second set of findings has connected CPT performance to anhedonia. The concept of anhedonia, or the inability to experience pleasure, has a long history in schizophrenia research and theory. Although not specific to schizophrenia spectrum disorders, anhedonia is widely thought to mark important schizophrenic processes (Bleuler 1911/1950; Chapman, Chapman, and Raulin 1976; Chapman, Edell, and Chapman 1980; Edell and Chapman 1979; Kirkpatrick and Buchanan 1990; Meehl 1964, 1975/1987, 1987; Venables, Wilkins, Mitchell, Raine, and Bailes 1990). Anhedonia is usually grouped with other "negative" or deficit

symptoms, such as blunted affect, and contrasted with "positive" symptomatology, such as bizarre beliefs and hallucinations.

Four studies have examined the relationship between anhedonia and CPT performance. Hain, Maier, Klingler, and Franke (1993) found no relationship between DS-CPT performance and anhedonia in schizophrenics, although a composite rating of negative symptomatology was significantly negatively correlated with d' scores. Nuechterlein et al. (1986) found schizophrenics' d' scores to be significantly related to ratings of emotional withdrawal, motor retardation and blunted affect; however, d' scores were also related to Rorschach-assessed thought disturbance. In our own study we found lowered hit rate on a dynamic CPT to be related to anhedonia, but only when positive schizotypal symptomatology was also present (Wilson and Costanzo 1995). In a recent path analytic study Erlenmeyer-Kimling et al. (1993) explored the relationships between impaired attentional performance (including impaired CPT performance) during childhood and later schizophrenia-related psychosis and social isolation. They found that the relation between attentional deviance and psychosis or social isolation was mediated by anhedonia. In short, when anhedonia was controlled for, there was no direct relation between attentional disturbance and schizophrenia.

Either a neurointegrative defect or anhedonia might readily explain the decreased processing capacity thought to characterize schizophrenics and those at risk for schizophrenia. Consistent with either a neurointegrative deficit, or reduced processing capacity, or anhedonia, cerebral glucose uptake in schizophrenics engaged in the DS-CPT has been shown to be reduced relative to normal controls, particularly in the prefrontal cortex (Buchsbaum et al. 1990; Guich et al. 1989). However, the presence of anhedonia and involvement of the motoric response system in the CPT also raises the broader question of subjective motivation and engagement in the CPT task, to which I now turn.

The Problem of Motivation and Signal Detection Indices in CPT Research

Evidence that motivation is related to CPT performance. A suitable level of involvement in the CPT protocol is necessary for the participant to produce responses. Because the CPT is rapidly paced, relatively rapid responses are required, and to make these responses, the participant must be oriented and willingly engaged in the task. Correlational evidence for a relationship between motivation and CPT performance has been provided by Hamilton, Haier and Buchsbaum (1984) and Hogan (1966). Using a dynamic 4-6 CPT, Hamilton et al. (1984) found commission errors and mean ISI to be significantly correlated with a measure of boredom coping ($-.36, p < .01$, and $-.43, p < .001$, respectively), indicating that those who coped with boredom more effectively were also better able to maintain task performance on the CPT. These investigators theorized that boredom coping was an active process that shifted attentional capacity towards interest and intrinsic enjoyment, and away from boredom. Using an A-X CPT apparently identical to the one developed by Rosvold et al. (1956), Hogan (1965) found that motivational levels, as assessed by a self-report measure, interacted with CPT trial block, such that participants with high motivation were less likely to make omission errors in later trial blocks than participants with low motivation.

As noted earlier, the early reports of increased omission errors in schizophrenics may have been reflecting a motivational, rather than attentional deficit. In fact, these early reports provide some evidence that motivation was an important element in schizophrenics' CPT performance. Almost all of Orzack and Kornetsky's research was conducted with the presumption that schizophrenics needed reinforcers to participate at suitable levels in the CPT (Kornetsky 1972). Latz and Kornetsky (1965) found that reinforcing correct responses to target stimuli with candy or cigarettes increased schizophrenics' response speed and decreased omission errors. Similar findings are reported in Orzack et al. (1967) using tokens as reinforcers. Later researchers have not pursued these findings systematically. When reinforcement has been used, it has not been controlled for with non-

reinforcement conditions (e.g., Cornblatt and Erlenmeyer-Kimling 1984; Rutschmann et al. 1986). Thus, the possible effects of motivation on CPT performance have not been studied extensively; where they have been studied, improvements in performance are significant.

A single but important exception to this rule is Nuechterlein's 1983 study of at-risk, hyperactive and control children, in which the amount and kind of immediate feedback participants received for correct and incorrect responses was varied. Perhaps surprisingly, d' scores for all three subject groups were higher during no feedback conditions than during the feedback conditions. The apparent inconsistency of these findings with those of Latz and Kornetsky (1965) and Orzack et al. (1967) may arise from the fact that immediate feedback in the form of pleasant bells for correct responses and aversive buzzers for commission errors is not equivalent to dispensing tokens or candy. Also, as I will argue below, none of these reinforcement/feedback conditions may provide the appropriate motivational set for optimal CPT performance.

Other signal detection studies of motivation. In addition to Nuechterlein's (1983) findings that feedback conditions failed to improve sensitivity, two other arguments have been put forth for the independence of perceptual sensitivity and motivation (Nuechterlein 1983; Nuechterlein et al. 1989). First is reliance on an oft-cited study in which auditory signal detection, computed as d' , was found not to vary significantly with level of motivation (Swets and Sewall, 1963). Three experimental manipulations were used, each purportedly increasing participants' motivational level. Participants were college students paid on an hourly basis for their participation. In the first condition, participants were inducted into the experiment casually by a research assistant, who took no interest in the experiment and who told participants that they were training rather than being tested. In the second condition, participants were met by the professor, who spent 30 minutes explaining the importance of the experiment, the support the experiment was receiving from the United States Armed Services, and the optimal strategy for improving detection scores. In the

third condition, participants were promised a large amount of cash (conceivably, up to 5 times what they were receiving on an hourly basis) for improved signal detection scores.

While Swets and Sewall concluded that d' did not vary with motivation at a statistically significant level, what has often been overlooked is that only *three* participants participated in this phase of the study, greatly limiting the power of the experiment. In fact, inspection of the data reveals that each of the three participants' d' scores did increase with the motivational manipulation, yielding an average increase from $d' = .91$ to $d' = 1.00$ (or about a 10% improvement). At best, the small sample size of Swets and Sewall (1963) offers only poor support for the independence of discriminability and motivation.

Indeed, a number of early signal detection studies of vigilance that were conducted outside the domain of schizophrenia research provide evidence that signal detection and motivation are not independent. These experiments manipulated motivation through a variety of methods, including (a) monetary rewards (Bevan and Turner 1965; Sipowicz, Ware, and Baker 1962), (b) privilege rewards (Ware, Kowal, and Baker 1964), (c) course credit rewards (Halcolm and Blackwell 1969) for correct target detection, (d) supervision by an authority figure or surveillance through a camera (Bergum and Lehr 1963; Putz 1975), (e) shock punishment (Bevan and Turner 1965) and (f) changes in experimenter attitude (Ware et al. 1964). By changing a single word in the instructional description of a vigilance task from "monotonous" to "challenging," Lucaccini, Freedy, and Lyman (1968) produced a significant difference in detection rates. All of the remaining studies cited here report similar improvements in overall detection rates and occasionally reductions in the vigilance decrement as a result of the motivation manipulation.

A more contemporary study of visual vigilance tested the effect of intrinsic interest on vigilance, and is to my knowledge the only such study to do so (Dember, Galinsky, and Warm 1992). Participants were either (a) led to believe they could choose either a difficult or an easy form of the vigilance task, or (b) told that they would be randomly assigned to

either the difficult or easy task condition. In fact, all participants were randomly assigned to difficulty condition regardless of choice. For participants with the illusion of choice, however, the decrement in detection rate over time was reduced, while the decrement in false alarm rate was not affected, relative to the performance of participants in the no-choice group. Although signal detection indices were not computed, these results indicate that the d' decrement was attenuated when participants were under the impression that they had a choice about which task they performed (Dember et al. 1992). This finding is all the more striking because the opportunity for choice was in fact illusory. Dember et al. (1992) suggest that the illusion of choice increased intrinsic motivation, which in turn increased vigilance performance. Thus, although studies such as Swets and Sewall's (1963) have not found these motivation effects, a strong claim that signal detection and motivation are independent does not seem tenable. (For further discussion of this issue, see Davies and Parasuraman 1982.)

Signal detection indices and motivation. The second argument put forth in support of the independence of d' and motivation is reliance on the signal detection indices themselves (Nuechterlein 1983; Nuechterlein et al. 1989). According to this argument, poor engagement in the CPT task should be reflected in high response criterion scores, or high $\ln \beta$ scores, not in impaired d' scores, and high levels of motivation should be reflected in low $\ln \beta$ scores, not increased d' scores. Indeed, signal detection indices were introduced into CPT research primarily to disentangle the effects of response bias and perceptual discriminability (Rutschmann et al. 1977). At least two assumptions are necessary for this argument. First, in accordance with signal detection theory, the argument demands that d' and $\ln \beta$ indices be independent. Second, the argument suggests that motivational levels will impact $\ln \beta$ scores, not d' scores.²

² A third assumption necessary to signal detection indices is that schizophrenics perform close to an idealized Receiver Operating Characteristic (ROC) curve. (ROC curves are determined empirically by instructing the subject to adopt different response criteria on different trials varying from liberal to

To date, only three studies have reported empirical tests of these assumptions with the CPT. In a study of at-risk children, Nuechterlein (1983) indeed found that d' and $\ln \beta$ indices were generally independent in the various CPT conditions he used. However, in a special response reversal condition of the CPT that required participants to press a button to every stimuli *except* the target (the digit 5), a significant negative correlation between d' and $\ln \beta$ scores emerged. The high response rate demanded by the task may have required a low response criterion in order to achieve high discriminability scores (Nuechterlein 1983). In contrast, Buchsbaum and Sostek (1980) found a very high *positive* correlation ($r = .66$) between d' and $\ln \beta$ with a dynamic, very rapidly paced A-X CPT. Finally, as already noted, Mussgay and Hertwig (1990) found a significant correlation between perceptual sensitivity and response bias using a highly modified version of the CPT. Because CPT versions vary greatly in terms of required response rate and other parameters, the independence of d' and $\ln \beta$ remains an important empirical question, one that is almost universally neglected.

Nuechterlein (1983) also tested the effect of auditory feedback on $\ln \beta$ scores. As noted above, both positive and negative feedback depressed d' scores, as if the feedback interrupted participants' ability to discriminate signals from noise. Feedback also affected response criterion, such that individuals who received positive feedback for correct responses had lowered $\ln \beta$ scores relative to those in the no feedback and negative feedback conditions. These results suggest that, if the feedback conditions affected

conservative, and plotting observed hit rates against false alarm rates.) At the time that signal detection indices were first being introduced into schizophrenia CPT research, this assumption was contested (Pigache 1976). Since then, ROC curves have not been reported in schizophrenia CPT research, so the assumption has gone untested.

Relatedly, formal signal detection theory requires the probability density distributions of signal and noise to be normal and of equal variance (Davies and Parasuraman 1982). It is not usually practical to test these assumptions in CPT research with schizophrenic participants. However, pilot work with one version of the CPT, the identical pairs playing cards, revealed that the protocol did not meet these distribution assumptions (Nuechterlein 1984b). This finding thus calls into question the appropriateness of using parametric signal detection indices with CPT data.

motivational levels, motivation in turn affected both d' and $\ln \beta$. An explanation for the depressed d' scores will be offered below.

Summary of CPT Research

Firm conclusions regarding the nature of the deficit or deficits displayed by schizophrenia-related populations during CPT performance are not currently possible. Given the absence of systematic manipulation of CPT task parameters, it is not possible to estimate the relative importance of stimulus encoding and more complex cognitive processes such as conceptual matching or response inhibition. Research supports only that processing load needs to be high in order for group differences in CPT performance to emerge. When these differences do emerge, only subgroups of the schizophrenic or at-risk samples perform differently than control samples. Steeper vigilance decrements have not been found for these populations, although more research is required before this possibility can be ruled out. Instead, when signal detection indices are utilized, the most common finding of CPT deficit is in perceptual sensitivity averaged over the course of the task. Performance seems closely related to the presence of anhedonia and neuromotor impairments, and I have argued that these findings in turn may be related to motivation.

Empirical evidence to date yields no convincing evidence that CPT performance is independent of motivation, even when signal detection indices are used. This conclusion should not be taken as a claim that all findings of discriminability deficits in schizophrenics and at-risk participants can be explained away as poor motivation. Rather, I am suggesting that the relationship between motivation and CPT performance may be important and has been greatly overlooked, a point that has also been made by Carson and Sanislow (1993). In this study I expected to find that motivation accounted for a significant portion of the variance in d' scores. That portion of the variance in d' not accounted for by motivation may then be a closer representation of the effect size for the heritable neurointegrative

deficit or limited processing capacity theorized to characterize schizophrenics and those at risk for schizophrenia spectrum disorders.

The Manipulation of Motivation: Deci and Ryan's Intrinsic Motivation Paradigm

If motivation and signal detection performance on the CPT are not independent, the question then arises of how best to test the relation between motivational states and perceptual sensitivity. With few exceptions (e.g., Dember et al. 1992; Lucaccini et al. 1968), previous studies investigating motivation and vigilance have used manipulations that may be termed "extrinsic" (Davies and Parasuraman 1982), that is, manipulations that involved the dispensation of rewards contingent on performance. In the CPT literature, the provision of tokens, candy, or pleasant auditory feedback contingent on correct detections are examples of such extrinsic motivation manipulations.

In contrast, Deci and Ryan (Deci and Ryan 1985a; Ryan 1982; Ryan, Koestner, and Deci 1991) have extensively investigated the effects of experimental inductions that facilitate intrinsic motivation, or the experience of freely persisting at a task in the absence of either external or internal pressure, with non-pathological participants. Because research on intrinsic motivation conducted by Deci, Ryan and their colleagues is extensive and has been summarized elsewhere (Deci and Ryan 1985a), only a brief summary will be offered here. These researchers distinguish between intrinsically motivated behavior and behavior that is controlled (either internally or externally) and motivated by performance pressure, behavior they sometimes refer to as "ego-involved" behavior (Ryan 1982; Ryan and Deci 1989; Ryan, Mims, and Koestner 1983; Ryan et al. 1991).

Among many empirical findings, this group has reported that performance-contingent feedback and rewards undermine intrinsic motivation (e.g., Ryan et al. 1983, 1991), whereas experimental inductions that (a) provide a rationale for engaging in the task, (b) orient the subject to the task in an informational rather than controlling, authoritarian manner, and (c) minimize the subject's experience of being controlled facilitate

intrinsic motivation (Deci, Eghrari, Patrick, and Leone 1994). Experimental conditions that are ego-involving and test-like produce less intrinsic motivation than do conditions that are task-involving and game-like (Koestner, Zuckerman, and Koestner 1987). Conditions that increase self-consciousness through video surveillance and mirror manipulations have a negative impact on intrinsic motivation (Plant and Ryan 1985). The interpersonal dynamics of the experimental condition can therefore either support or undermine autonomy, which Deci and Ryan (1987) describe as the inner endorsement of one's actions, and autonomy in turn is a prerequisite for the emergence of intrinsic motivation (Deci and Ryan 1987; Grolnick and Ryan 1987; Ryan and Deci 1985).

No previous CPT studies have attempted to investigate the relationship between intrinsic motivation and performance. Arguably, however, experimental conditions that maximize intrinsic motivation might also maximize perceptual sensitivity in CPT performance: under these conditions perceptual, attentional and neuromotor response systems should be optimally engaged in the task. In addition, being intrinsically motivated should reduce distracting self-conscious thoughts about performance. If Nuechterlein's (1991) suggestion that CPT deficits are produced by sporadic, transitory interruptions in attention is correct, these interruptions should be minimized if the CPT task is made as intrinsically motivating as possible. In contrast, the engagement of attention through external rewards and performance feedback during the CPT might increase "self-surveillance" (Deci and Ryan 1987) and performance pressure, thereby producing less than optimal attentional engagement (Deci and Ryan 1985b). This hypothesis might explain the lower d' scores under conditions of auditory feedback found by Nuechterlein (1983), as well as Latz and Kornetsky's (1965) and Orzack et al.'s (1967) findings that although schizophrenics' CPT performance improved under conditions of positive reinforcement, it still remained impaired relative to that of control participants. Thus Deci and Ryan's (1985a) intrinsic motivation paradigm appears to provide a stronger test of a relationship

between CPT signal detection performance and motivation than would performance-contingent rewards or feedback.

As described in more detail below, the motivational conditions employed in this study closely followed Deci et al.'s (1994) inductions with a low processing load vigilance task. In that study, participants simply had to respond by pressing the space bar on a keyboard every time a dot appeared on a computer monitor; this response caused the dot to disappear, and a new dot would reappear somewhere else on the computer screen once every 2 to 8 seconds. The total duration of the task lasted 5 minutes, and participants found the protocol "quite boring" (Deci et al., 1994). This study did not report any vigilance performance scores, but instead relied on persistence at the vigilance task during free time as a measure of intrinsic motivation. Here, I directly tested the relationship between a modified version of Deci et al.'s motivation inductions and signal detection performance.

Thus, this dissertation examined a number of potential predictors of attentional impairment that is the putative marker for a schizophrenia-related neurocognitive vulnerability. The broad context for this inquiry was constituted by the web of significant interpersonal relationships that accompany and guide participants' development. This interpersonal context was conceptualized in terms of adult attachment, because in many ways the concept of adult attachment captures the distillate of interpersonal dynamics, bearing as it may the composite traces of multiple interactions with caregivers and peers. In turn, individual differences in attachment provide a very potent measure of both resilience and risk of psychopathology. As I previously emphasized, consideration of such individual differences is essential in order to investigate the implications that attentional impairments may have for understanding the genesis of schizophrenia spectrum disorders.

Specific Aims

The objective of this research is to examine the relationship between schizotypy and signal detection indices of attentional processes, and to explore whether this relationship is affected by attachment history and motivational level. The study had five specific aims.

1. The first aim of this study was to replicate findings of associations between impaired attachment processes in young adults and increased likelihood of schizotypy. Specifically, findings from my prior work indicated that positive schizotypy, or a tendency towards odd perceptual and cognitive processes, was associated with anxious attachment style, while negative schizotypy, measured as anhedonia, was associated with avoidant attachment. Secure attachment was associated with neither positive nor negative schizotypy (Wilson and Costanzo 1995). I sought to replicate and extend these findings with a larger sample. In particular, including measures of recalled attachment to parents and peers in childhood permitted me to assess the relationship between early interpersonal relations retrospectively reported, current adult attachment, and schizotypal tendencies.

2. The second aim of this study was to replicate findings of an association between schizotypy and impaired perceptual sensitivity, using Nuechterlein's degraded stimulus CPT (DS-CPT; Nuechterlein, 1983; Nuechterlein, Parasuraman, and Jiang 1983) in a large sample of college students. As already reviewed, impaired perceptual sensitivity appears to be associated primarily with the presence of negative schizophrenic symptoms such as anhedonia (Cornblatt and Keilp 1994; Erlenmeyer-Kimling et al. 1993; Nuechterlein 1983; Nuechterlein et al. 1986). A number of studies have also identified a relationship between attentional impairment and positive schizophrenic symptoms, or between attentional impairment and both positive and negative symptoms (Grove, Lebo, Clementz, Cerri, Medus, and Iacono 1991; Nestor et al. 1990; Nuechterlein et al. 1986; Obiols et al. 1992; Wilson and Costanzo 1995). However, the precise relationships between attentional measures such as those derived from CPT research and actual symptomatology in

schizophrenics has received only limited attention (Cornblatt, Lenzenweger, Dworkin and Erlenmeyer-Kimling, 1985; Neale, Oltmanns and Harvey, 1985; Nuechterlein et al., 1986). Thus, this study was designed to clarify the relationships between attenuated schizophrenia spectrum symptomatology and CPT performance in psychometrically identified participants.

3. The third aim of this study was to confirm the independence of attachment history and performance on the DS-CPT. Such confirmation is important, given the fact that development of attentional processes takes place in a social context with historical interpersonal antecedents (e.g., Main, Kaplan, and Cassidy 1985). Early dissertation findings of Main (1972; in Bretherton 1985), as well as independent work reported by Erickson, Sroufe, and Egeland (1985), and Jacobsen, Edelstein, and Hofmann (1994) suggest that attentional processes are not independent of attachment history, and that when attachment is impaired, attentional problems are more likely. The lack of such a relationship found in my pilot study (Wilson and Costanzo 1995) may have resulted from using a CPT protocol that was insufficiently challenging and predominantly motoric. On the other hand, if attachment and CPT performance are independent, then the view that impaired perceptual sensitivity is a heritable biological vulnerability factor is strengthened. With the exception of Wilson and Costanzo (1995), this relationship has gone untested, and the "diathesis" status of the attentional deficit has been presumed.

4. The fourth aim of this study was to assess the effect of motivational levels on performance during the DS-CPT protocol. As discussed earlier, given the association of impaired CPT performance with anhedonia and the motoric demands of the task, motivation during the CPT protocol would appear to be particularly relevant to performance. However, motivation has been manipulated in CPT studies only rarely, and the guiding assumption of this work has been that motivational factors do *not* affect

perceptual sensitivity (e.g., Nuechterlein 1983; Swets and Sewall 1963). The present study was designed to test that assumption rigorously.

Evidence for the involvement of motivation in schizophrenics' performance on cognitive tests dates back over 30 years (e.g., Andorfer, Shimkunas, and Sciarini 1975; Buss and Lang 1965; Carson 1971; Fontana and Klein 1968; Pascal and Swensen 1952; Shakow 1962). Contemporary research has shown that cognitive deficits exhibited by schizophrenics on Wisconsin Card Sorting protocols are effectively eliminated when instructional and motivational interpersonal sets are established (Green, Ganzell, Satz, and Vaclav 1990; Green, Satz, Ganzell, and Vaclav 1992; Liberman and Green 1992).

In the current study, motivational set in DS-CPT performance was manipulated through either (a) an informational induction that has been shown to facilitate intrinsic motivation, (b) a controlling induction that reduces intrinsic motivation, or (c) a standard condition without any induction (Deci et al. 1994). I expected that participants' perceptual sensitivity would increase under conditions that facilitated a sense of self-determination and intrinsic interest in the task. In essence, this manipulation treated the experimental setting itself as a social situation, in which participants' interpersonal responses to the experimenter's presentation of the DS-CPT protocol were considered determinative factors of attentional performance.

5. The final aim of this study was to replicate my pilot finding, discussed earlier, that attachment and attentional processes, while independent, interact to determine the likelihood of schizotypal disturbances. This finding appeared to provide strong support for the diathesis-stress model of schizophrenia, and is one of the few statistically significant findings that a non-linear combination of psychosocial and neurocognitive factors predicts schizotypal tendencies. Replication of this finding with a larger sample and a CPT protocol that permitted me to disentangle response strategy from perceptual sensitivity was an important step in understanding this interaction.

In summary, the broad purpose of this study was to examine whether (a) interpersonal factors such as attachment history and experimentally influenced motivational levels affected attentional processes measured in the CPT protocol, and (b), if they did, whether the influence of these factors was independent of the expected schizotypy-related deficit in attentional performance. Thus, this study was designed to test the assumption that schizophrenia-related deficits in perceptual sensitivity are unaffected by interpersonal factors, and therefore accurately index a heritable neurocognitive vulnerability that contributes to schizophrenia diathesis. Finally, this study tested the diathesis-stress model of schizophrenia, using attentional performance as an index of the diathesis and attachment as an index of psychosocial stress.

METHOD

Participants

Over the three semesters that this study was conducted, 703 undergraduates (53% women) completed attachment, schizotypy, and causality orientation questionnaires during group testing as a routine requirement of their introductory psychology classes. Participants' ages ranged from 17.25 to 41.33 years, ($M = 19.3$ years), and there were no sex differences in age ($p > .24$). Questionnaires, described below, consisted of (a) the Hazan and Shaver (1987) trichotomous measure of attachment, (b) Collins and Read's (1990) dimensional Adult Attachment Scale, (c) Venables, Wilkins, Mitchell, Raine, and Bailes' (1990) Survey of Attitudes and Experiences, a scale of schizotypy, and (d) Deci and Ryan's (1985b) General Causality Orientations Scale. Based on their schizotypy scores, a subset of these participants ($n = 191$, mean age = 19.3 years, 53% female) then completed the DS-CPT protocol and related questionnaires in return for course credit. DS-

CPT participants included two older students (a male aged 27 and a female aged 41) who were retained in analyses after no effects for age were found for DS-CPT measures. The majority (78.5%) of DS-CPT participants were Caucasian; 9.4% were African American, 7.3% were Asian, 3.7% were Asian Indian, and 1% were Hispanic.

Measures

Hazan and Shaver's (1987) Trichotomous Measure of Attachment. This measure consists of a single item that asks participants to select one of three descriptions of their own attachment style corresponding to Ainsworth et al.'s (1978) classic description of secure, avoidant and anxious/ambivalent attachment styles. Inclusion of Hazan and Shaver's (1987) measure permitted links to be made with existing attachment literature that employs categorical analysis. The measure is included as item 1 of the composite questionnaire in Appendix B.

Collins and Read's (1990b) Adult Attachment Scale, Revised. This scale consists of 18 items that load on 3 correlated attachment factors which Collins and Read (1990a) termed Depend, Close and Anxiety. Each item is rated on a 5-point Likert scale ranging from . Items 2-19 of the composite questionnaire (Appendix B) comprise the Adult Attachment Scale.

Venables et al.'s (1990) Schizotypy Scale (modified). This instrument consists of 27 questions that have been found to measure either positive schizophrenia (a tendency towards thought disorder and bizarre beliefs) or anhedonia in the normal ranges of human experience. This scale was originally constructed with true-false response options. However, dichotomous data are susceptible to extreme distortions in inter-item correlations and thus impede replication of factor solutions (Comrey 1988; Watters, Thomas, and Steiner 1990). Consistent with Comrey's (1988) recommendations, I modified the questionnaire to allow a range of endorsement for each item on a 5-point Likert score

anchored by *not at all characteristic* (1) and *very characteristic* (5). This questionnaire comprises items 20-46 of the composite questionnaire (Appendix B).

Epstein's (1983) Mother-Father-Peer Scale. Epstein's Mother-Father-Peer scale (MFP) consists of a total of 70 items, 30 each assessing the participant's recalled childhood attachment to her mother and father, and 10 items assessing recalled attachment to childhood peers. Like the other questionnaires, each item is rated on a 5-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (5). For childhood attachments to mother and father, three subscales have been developed: (a) independence-encouragement versus overprotection, (b) acceptance versus rejection, and (c) parent idealization. The childhood peer questions comprise a single acceptance-rejection scale. The MFP consists of items 47-116 of the composite questionnaire (Appendix B).

Deci and Ryan's (1985b) General Causality Orientations Scale. This instrument consists of 12 vignettes. For each vignette, participants are asked to rate how characteristic each of three possible responses would be. Each of these responses represents one of three correlated causality orientations: (a) autonomy, which is characterized by intrinsic motivation and a high degree of experienced choice with respect to one's behavior, (b) control, which is characterized by the experience of being controlled by factors either in the environment or within the participant (e.g., "ego involvement"), and (c) an impersonal orientation involving the experience of one's behavior as being beyond intentional control. This instrument comprises items 117-152 of the composite questionnaire (Appendix B).

Degraded Stimulus Continuous Performance Test (DS-CPT). Following completion of the group testing materials, a subset of participants were asked to return and complete a computerized version of Nuechterlein's DS-CPT (Nuechterlein and Asarnow 1992/1993, Version 6.07), made available for this study by Dr. Nuechterlein through the UCLA Clinical Research Center for the Study of Schizophrenia. DS-CPT participants were selected based on their schizophrenism and anhedonia scores from the Venables et al.

(1990) instrument, and assigned to one of three motivational induction conditions (described below) in a staggered random design. For each condition, a minimum of 20 participants with anhedonia scores one standard deviation above the mean, 20 with schizophrenia scores one standard deviation above the mean, and 20 with anhedonia and schizophrenia scores deviating from the mean by less than half a standard deviation were selected. Each of these cells had almost equal numbers of males and females. The experimenter was blind to participants' scores on all questionnaires at the time that participants completed the DS-CPT.

All participants completed the DS-CPT in the afternoon, to control for time of day effects. With the exception of the motivational inductions included in this study, all specifications for the DS-CPT contained in Nuechterlein's unpublished manual (Nuechterlein January 1994) were strictly followed. The DS-CPT was run using an IBM-compatible 486-SX with a VGA graphics system, a NEC MultiSync 3FGe monitor, and an Advanced Gravis Analog Controller Joystick as the input device for participants' individual responses to displayed stimuli. A non-magnetic light meter with a flat diffuser was used to establish specified brightness and contrast readings for the monitor.

To ensure that impairments in participants' visual acuity did not undermine the validity of DS-CPT performance, participants' eyesight was tested using a miniature Snellen eye chart; no participants were disqualified from participating on the basis of poor visual acuity. Following this acuity screening, participants were seated one meter from the monitor and received DS-CPT instructions. Participants held the controller joystick in their lap with both hands, and used the thumb of their dominant hand to press a button on the joystick whenever they perceived a target. In this version of the DS-CPT, stimuli were the digits 0 through 9, with 0 as the designated target; all stimuli backgrounds were degraded through a 40% random pixel reversal; targets had a 25% probability of occurring, and stimuli were presented at the rate of one per second. Participants first were exposed to a

quasi-random sequence of 80 demonstration stimuli, with stimuli exposed for 330 msec, during which participants practiced responding to the target 0 by pressing the controller joystick. Participants then completed a practice period of 160 stimuli presented for 33 msec each, followed by a rest period of two minutes. Finally, participants completed a test period involving the presentation of 480 stimuli for 33 msec each. Total time spent engaged in the DS-CPT was approximately 12 minutes. From the standpoint of the subject, this test period was continuous, but programming permitted analysis by six sequential blocks. For each block, scores for hit rate, false alarm rate, reaction times, and nonparametric indices of perceptual sensitivity (A') and response bias (B'') were computed.³ Summary scores averaged across all six blocks for each of these measures were also computed.

The three motivational induction conditions to which participants were assigned differed only slightly from each other. Pursuant to Nuechterlein's DS-CPT manual (January 1994), all participants regardless of motivational induction condition were told that detecting targets correctly and avoiding false alarms were equally important. The first induction condition to which participants were assigned followed the standard DS-CPT

³ These indices are analogous to the d' and $\ln\beta$ indices, respectively. As discussed earlier (Footnote 1), nonparametric indices are appropriate, as here, when the underlying assumptions required by signal detection theory -- the normalcy and homoscedasticity of the signal and noise probability density distributions -- cannot be tested (Nuechterlein 1991). The nonparametric perceptual sensitivity index A' is given by the formula

$$A' = .5 + \frac{(\text{hit rate} - \text{false alarm rate})(1 + \text{hit rate} - \text{false alarm rate})}{4(\text{hit rate})(1 - \text{false alarm rate})}$$

(Grier, 1971, equation 2). An A' score of .5 thus represents perceptual discrimination at a chance level, while an A' score of 1.0 represents perfect perceptual discrimination of target and non-target trials. The nonparametric response bias index B'' is given by the formula

$$B'' = \frac{(\text{hit rate})(1 - \text{hit rate}) - (\text{false alarm rate})(1 - \text{false alarm rate})}{(\text{hit rate})(1 - \text{hit rate}) + (\text{false alarm rate})(1 - \text{false alarm rate})}$$

(Grier 1971, equation 11). B'' scores range from -1 to +1, with scores nearer to -1 representing very liberal response biases and scores nearer to +1 representing very conservative response biases. Use of nonparametric signal detection scores represents an advance over parametric measures, because the nonparametric measures are appropriate regardless of the shape of the underlying distributions.

protocol (the "standard" condition). In all, 35 females and 30 males completed this standard condition of the DS-CPT. Following Deci et al. (1994), the second condition was designed to elicit an experience of intrinsic motivation and autonomy while completing the DS-CPT (the "intrinsic motivation" condition). During the two-minute rest period between practice and test trial, the experimenter provided participants with the following motivational induction, based largely on induction protocols used by Deci et al. (1994) and by Rathunde, Hamilton, and Csikszentmihalyi (1993):

The task that you have been engaged in has been found useful. Participants who have completed this task have learned about their own concentration, since the task involves focused attention that is important for concentration. This is the type of task that air-traffic controllers use in order to enhance their signal detection abilities. People vary in their experience of this task; some people find it kind of boring and others have found it pretty interesting. We are still piloting this procedure, so any errors you might make will be deleted from your record at the end of the day. What we are interested in is your experience of the task, and after completing it I'll ask you to fill out two short questionnaires about it.

Thirty-three females and 30 males completed the DS-CPT under the intrinsic motivation condition.

Finally, the third motivational condition was designed to induce an experience of high external control and low autonomy while completing the DS-CPT (the "low autonomy" condition). During the two-minute rest period, the experimenter read the following induction to participants, which was again closely modelled on Deci et al. (1994) and Rathunde et al. (1993):

The task you have been doing is a very sensitive measure of perceptual cognitive functioning. It will show how well you are able to distinguish visual forms. Preliminary research indicates that doing well on this task is related to higher levels of performance on a number of other tests of intelligence and creativity that require rapid processing of information. As you proceed with the task, any errors you make will be stored in the computer, so try to do as well as you can. Also, try to keep track of any errors you make. Although your scores will later be compared with other students in order to see how you do, we will keep your name confidential.

After completing the task, I'll ask you to fill out two short questionnaires about it.

Unlike the intrinsic motivation induction, the low autonomy induction was designed to focus participants on their performance and emphasized meeting external standards. In Deci and Ryan's terms, this induction should elicit heightened levels of self-surveillance and ego-involvement (Deci and Ryan 1987; Ryan et al. 1983, 1991). Thirty-three females and 30 males completed the DS-CPT under the low autonomy condition.

Post-experimental measures. To assess the impact of the motivational inductions, participants filled out a brief questionnaire after they completed the DS-CPT, the Intrinsic Motivation Inventory (Appendix C). This instrument was developed by Deci, Ryan and their colleagues (e.g., Plant and Ryan 1985; Ryan 1982; Ryan et al. 1991). Five subscales have been derived factorially from this scale: interest-enjoyment, competence, effort-importance, pressure-tension, and choice. In the version used here, each subscale contained four or five items which were rated by participants on a scale from *strongly disagree* (1) to *strongly agree* (7). In Deci and Ryan's research, interest-enjoyment, competence, effort-importance, and choice increase, while pressure-tension decreases, under intrinsic motivation inductions; the reverse pattern holds for controlling, low autonomy motivation inductions.

Participants also were asked to rate the degree to which they experienced emotions during the afternoon, including the experimental session, on a scale from *not at all* (0) to *very* (8). Participants rated 11 emotions on these scales: amusement, anger, arousal, contemptuousness, contentedness, disgust, embarrassment, fear, sadness, happiness, and tension. Because participants were asked to rate their general mood over a time period that was greater than the experimental session, I did not expect that this measure would vary by motivational condition. However, inclusion of this instrument permitted assessment of relationships between emotional experience and attentional performance, and between emotional experience and attachment style.

In addition, as a secondary index of effort, DS-CPT participants completed a simple motor task of depressing a hand-held Dynamometer to 50% of their maximum capacity for as long as they were able. By adjusting the criterion individually to 50% of participants' maximum level of strength, this procedure controlled for individual differences in physical strength. Thus, the length of time that participants held the Dynamometer before the gauge dropped 5% below the 50% mark was the variable of interest.

Finally, to assess the specificity of Venables et al.'s (1990) anhedonia scale, the Mood Disorder subsection of the Structured Clinical Interview for DSM-III-R (Spitzer, Williams, Gibbon, and First 1988) was administered to all DS-CPT participants.

ANALYSIS AND RESULTS

Overview of Analyses

Step 1: Measurement models. Measurement models were developed individually for each of the eight questionnaires, using confirmatory factor analysis in the context of covariance structural analysis (Bollen 1989).⁴ This step provided empirical confirmation of the latent variable (factor) structures hypothesized to underlie the observed covariances

⁴ For several reasons, confirmatory, rather than exploratory, factor analyses were appropriate for the development of these measurement models. First, there already existed sufficient empirical work to provide the basis for seeking to confirm the hypothesized factor structures underlying these data (Long 1983). Most of the instruments had been factor analyzed previously, but even in the instances where this was not the case (Epstein's Mother-Father-Peer Scale and the emotion instrument used with DS-CPT participants), evidence was sufficient to specify factor structures. Second, arguments to the contrary notwithstanding (Nesselroade 1994), confirmatory factor analysis possesses a number of substantial advantages over exploratory factor analysis. In confirmatory factor analysis, the factor model can be specified a priori and exactly, in accordance with clear theoretical or prior empirical work, and the goodness of fit of this model to the data can be assessed through several indices, some of which are relatively independent of sample size. By contrast, in exploratory factor analysis a number of post hoc judgment calls must be made by the investigator (e.g., the number of factors to retain and the degree to which they should be rotated), and the factor model itself cannot be specified as exactly as it can in confirmatory factor analysis (e.g., all questionnaire items must be permitted to load on all factors, rather than constrained to load on only the factor(s) thought to be relevant). These weaknesses in exploratory factor analysis can lead to relatively arbitrary decisions that jeopardize the substantive meaningfulness of the model (Bollen 1989; Goldstein and Dillon 1984). Moreover, the chi square goodness of fit test for exploratory factor analysis can be highly misleading with large data sets, because the increased power provided by large data sets allows even trivial amounts of common covariance to force a rejection of the factor model (see Bollen and Long [1993] for a related discussion in the context of confirmatory factor analysis).

in questionnaire items, and also formed the basis for computing the factor scores employed in the subsequent four steps of analysis.⁵ When theoretically meaningful, second order factor solutions were also fit, thereby providing a superordinate factor that summarized the covariance among the first order factors. These superordinate factors provided additional parsimony in summarizing data and were therefore used in subsequent analyses when multicollinearity would have otherwise been problematic.

Step 2: Attachment style relationships. The relationships between the three classical attachment styles and all variables of interest were explored using ANOVA's. This phase of analysis was in part exploratory and in part an attempt to replicate findings from Wilson and Costanzo (1995). Confirmation of attachment style differences in adult attachment and schizotypy factor scores, but not in attentional performance, represented the replication portion of these analyses; investigation of attachment style differences in causality orientation, intrinsic motivation, emotional experience, effort, and history of mood disorders represented the exploratory portion of these analyses. Although not a central question for this study, the use of intrinsic motivation, effort, emotion, and mood disorder measures following the DS-CPT afforded an opportunity to explore whether

⁵ Factor scores are estimates of the value of the latent factor for individual observations. They have a mean of zero and variance equal to the squared multiple correlation of the factor with the indicator variables (SAS Institute 1990). Bollen (1989) has criticized over-reliance on factor scores, because it is possible for a single observation to have non-identical factor score estimates for the same latent factor. Nevertheless, using factor scores can reduce the measurement error present in unadjusted (observed) variables (Bollen 1989).

The alternative to using factor scores as surrogates for latent variable values is to conduct structural equation modelling with latent variables. Although Bollen (1989) champions this method, employing structural equation modelling with latent variables is prohibitively expensive in terms of degrees of freedom with the current sample. Alone, the eight measurement models developed involved estimating over 150 parameters. Depending on the specifications of the structural equation model, most or all of these parameters would need to be estimated simultaneously with the parameter estimates of the structural (predictive) components of the model. Given the modest rule of thumb for estimating parameters of maintaining a 10:1 ratio of observations to parameters, two to three thousand participants would be required in order to obtain reasonably stable estimates for these parameters. Although my sample of 700 is large by current standards, the parameter density of any such structural equation model is prohibitive. Use of factor scores computed from sequentially assessed confirmatory factor models represents a reasonable compromise between the demands for measurement accuracy and the limitations of a finite sample.

attachment style was associated with differences along these dimensions. Alpha was set at .05 at a familywise level, with families of comparisons designated for attachment dimensions, causality orientation, intrinsic motivation, emotional experience, effort, and mood disorder. Significant between-group differences were followed up using Tukey's method to control for Type I errors.

These analyses were conducted using two closely related methods of partitioning participants into secure, avoidant, and anxious attachment styles. First, participants' self-classifications on Hazan and Shaver's (1987) trichotomous instrument were used as indicators of attachment style. Second, participants' factor scores from Collins and Read's (1990b) Adult Attachment Scale were cluster analyzed, and groupings from a three-cluster solution were used as indicators of attachment style. The two methods provided convergent validity for group differences, and also permitted comparison with prior findings (Collins and Read 1990a; Wilson and Costanzo 1995).

Step 3: Path analysis of attachment and schizotypy. Path analyses using factor scores⁶ were conducted to identify significant relationships between perceived parental patterns, current attachment, and psychopathological propensity, using the entire sample. I used this method to test indirect (mediated) and direct effects in the prediction of schizotypal and anhedonic tendencies and to explore sex differences in these relationships (Bollen 1989).

Step 4: DS-CPT performance relationships. The relationship between participants' DS-CPT performance and variables of interest was investigated. These analyses took place in four substages. First, because the three motivational induction conditions were of central importance in this study, I confirmed that no between-condition differences existed

⁶ This stage of analysis is equivalent to structural equation modelling with latent variables, with the exception that the term "path analysis" is reserved for structural equation modelling with observed, not latent, variables. Considerations regarding the use of path analysis with factor scores rather than latent variable modelling are discussed in footnote 5.

on relevant dimensions, such as anhedonia and schizophrenia. Second, I explored whether the motivational inductions influenced Intrinsic Motivation Inventory and effort scores. Third, I confirmed that the DS-CPT operated as a true vigilance task, and that the non-parametric signal detection indices conformed to signal detection requirements. Fourth, participants' change in DS-CPT performance over time was modelled using growth curve analyses. Growth curve analysis is a well-established technique for simultaneously modelling individual change as a function of time and group differences in change as a function of predictor variables. This method of analysis is described in detail later.

Step 5: Prediction of schizotypal tendencies from a diathesis-stress model. Finally, I explored interactive models predictive of psychopathological tendencies. These models were derived from the resilience (e.g., Garmezy 1994; Garmezy, Masten, and Tellegen 1984) and diathesis-stress (Nuechterlein 1987; Nuechterlein and Dawson 1984a; Zupin and Spring 1977) literatures. In the pilot predecessor of this study (Wilson and Costanzo 1995), attachment and attentional performance, although independent, interacted to predict anhedonia. In this fifth section of analyses, I sought to replicate this finding using attachment factor scores and DS-CPT performance as copredictors of anhedonia and schizophrenia.

Step 1: Measurement Models

Confirmatory factor analyses were conducted separately on each set of questionnaire items using the Maximum Likelihood Method of estimating covariance parameters.⁷ In each case confirmatory factor analysis involved a series of stages, first

⁷ The Maximum Likelihood Method is the most widely used fitting function for structural equation modelling in general and confirmatory factor analysis in particular (Bollen 1989). A full description of the processes involved in the Maximum Likelihood Method is beyond the scope of this dissertation. In essence, this method involves an iterative process in which the joint likelihood of obtaining observed values for the variables under consideration is maximized by identifying an optimal set of structural parameters. In other words, parameter estimates are iterated until the covariance matrix computed from these estimates comes sufficiently close to (maximizes the likelihood of obtaining) the observed covariance matrix. Once a solution is converged upon, estimates of the multivariate residual, goodness of fit, and variances accounted for are available to assess whether the hypothesized covariance structure adequately and parsimoniously replicates the observed covariance matrix (Bollen 1989; Dillon and Goldstein 1984).

fitting all questionnaire items under consideration and assessing the goodness of fit, and then successively dropping questionnaire items that failed to contribute significantly to the hypothesized factor structure. In practice, most factor loadings had to be substantially greater than .5 in order to achieve appropriately fitting models.⁸ Although some individual items failed to contribute to the overall measurement models, the underlying factor structures I tested were generally confirmed. In several cases, these models were enhanced compared to prior measurement constructs through the identification of superordinate variables (i.e., second order solutions) that accounted for shared variance among the first order factors. Identification of appropriately fitting measurement models generally required several successive attempts; only the optimal measurement models are reported.

Venables et al.'s (1990) Schizotypy scale. In a series of prior factor analyses with large samples, Venables et al. (1990) and Wilson and Costanzo (1995) identified two factors underlying this instrument when items were dichotomous. This structure was tested and, once low-loading items were eliminated, confirmed with the current sample ($n = 680$) using identically worded items rated on a scale from (1) to (5). The final model, with factor loadings, is shown in Figure 1.⁹ Goodness of fit indices were excellent for this

⁸ Removal of low-loading items results in reduced numbers of indicators for each underlying factor. Such a reduction in indicators can be problematic in scales constructed of equally weighted items, because a restricted number of items can result in restricted scale variability and lowered internal consistency coefficients. However, balanced against such considerations are the benefits of eliminating noise and obtaining measurement models that more clearly represent the hypothesized constructs of interest. Additionally, the use of factor scores (which involve proportional rather than equal weighting of questionnaire items) preserved interindividual variability in scores.

⁹ An important omission from this and subsequent figures is the error, or disturbance, terms. Disturbance terms are unobserved random variables that represent measurement error, or the net influence of many variables that influence the observed variables only slightly or that are unknown (Bollen 1989). Together with the latent factor, disturbance terms determine the value of the observed covariance matrix. In all confirmatory factor analyses reported here, the disturbance terms are assumed to be homoscedastic and uncorrelated either with each other or with the latent factors. These assumptions represent the most stringent constraints on the disturbance terms. While it is possible and under certain circumstances appropriate to loosen these assumptions, doing so in the current context would have compromised the meaning of the final measurement model. For instance, allowing disturbance terms to be correlated with each other effectively assumes the existence of another latent factor that accounts for common variance among the disturbance terms, and hence among the observed variables. Thus, although obtaining improvement of fit indices is possible with less stringent assumptions regarding measurement errors, such

model: Goodness of Fit Index Adjusted for Degrees of Freedom, .9753; Bentler's Comparative Fit Index, .9824; Bentler and Bonett's Non-normed Index, .9767; Bentler and Bonett's Normed Index, .9534; Bollen's Normed Index Rho1, .9383; Bollen's Non-normed Index Delta2, .9826; root mean square residual, .0533.¹⁰

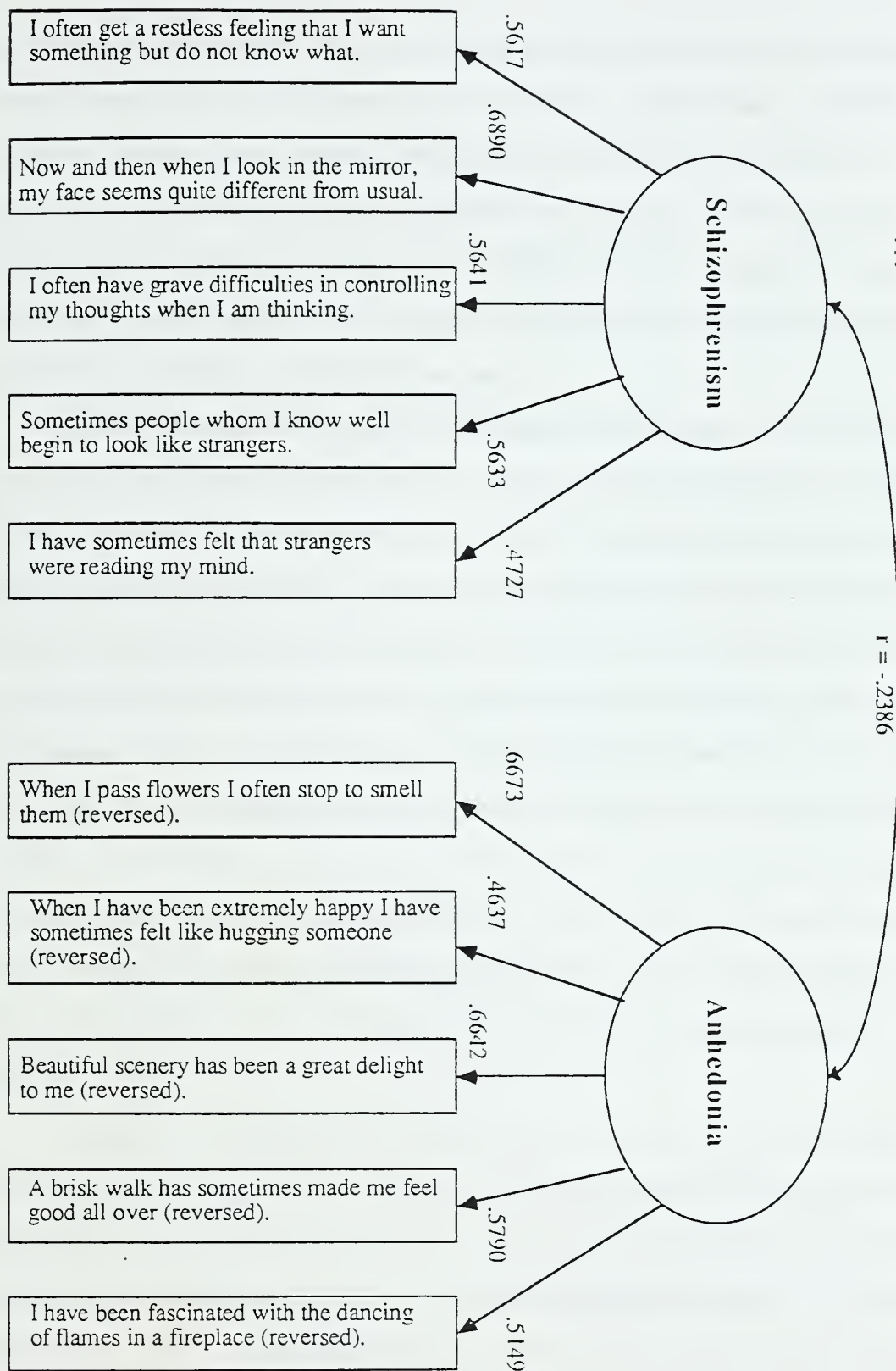
The two factors identified in the solution shown in Figure 1 -- anhedonia and schizophrenia -- are conceptually identical to those identified by Venables et al. (1990) and Wilson and Costanzo (1995). However, fewer items contributed to the current model than had been found in prior solutions, and the modest negative correlation between the factors differed from the nearly orthogonal factor structure found by Venables et al. (1990) and the modest positive interfactor correlation found by Wilson and Costanzo (1995). Importantly, however, this correlation replicated almost exactly the negative correlations reported for very similar scales given to over 5,500 undergraduates (Chapman, Chapman, and Miller 1982).¹¹ Differences in interfactor correlations and item loadings may have resulted from using (a) rated rather than dichotomous data (Comrey 1988) and (b) more stringent factor loading requirements compared to those reported by Venables et al. However, the common finding of negative (anhedonia) and positive (schizophrenism) schizotypy dimensions across studies suggests that these constructs are robust to

techniques often obscure the degree to which the latent factors explicitly set forth in the model are actually measured. (See Jöreskog [1993] for additional discussion of this point.)

¹⁰ Assessing the goodness of fit in structural modelling is a rapidly developing field, and a number of complementary indices are available and reported here. In terms of these indices, well-fitting models are identified by a profile of fit indices above .90 and a root mean square residual close to zero. Because it is possible to obtain high values for overall fit indices while retaining components of the model which fit poorly, or under conditions that are sample rather than conceptually driven, two important additional criteria for acceptance of a model are the acceptability of model components -- indicated in the case of these measurement models by the strong factor loadings -- and the substantive meaningfulness of the model -- indicated here by the content of the individual measurement items (Bollen and Long 1993).

¹¹ The Chapmans' Perceptual Aberration and Magical Ideation Scales correlated at -.22 and -.23, respectively, with the Chapmans' Physical Anhedonia Scale. The current Schizophrenism and Anhedonia measures were derived from all three of these scales (Venables et al. 1990) and, as noted in the text, closely resemble these measures.

Figure 1. Confirmatory Factor Solution for Venables et al.'s (1990) Schizotypy Scale



measurement variance (see Vollema and van den Bosch [1995] for similar conclusions). It should be pointed out that the majority of items loading in the final solution were identical in wording to items in the Chapmans' Perceptual Aberration, Magical Ideation, and Physical Anhedonia scales (Chapman, Chapman, and Raulin 1976, 1978; Eckblad and Chapman 1983), from which Venables et al. (1990) derived their own scale. Thus, the measurement model identified with the current sample shares considerable resemblance to the Chapmans' measures of psychosis-proneness.

Collins and Read's (1990b) Adult Attachment Scale, Revised. Prior factor analyses with this and the original version of the Adult Attachment Scale identified three correlated factors: (a) Anxious, or the amount of anxiety elicited in connection with concerns about abandonment and reciprocation of feelings in important relations; (b) Close, or how comfortable participants were in becoming close with others; and (c) Depend, or the extent to which participants felt able to depend on others (Collins and Read 1990a, 1990b; Wilson and Costanzo 1995). After eliminating questionnaire items that contributed poorly to the model, this same three-factor solution was confirmed with the current sample ($n = 689$). Goodness of fit indices were quite good: Goodness of Fit Index Adjusted for Degrees of Freedom, .9250; Bentler's Comparative Fit Index, .9616; Bentler and Bonett's Non-normed Index, .9484; Bentler and Bonett's Normed Index, .9498; Bollen's Normed Index Rho1, .9327; Bollen's Non-normed Index Delta2, .9617; root mean square residual, .0605.

Interfactor correlations were in the same direction but larger than those reported with the original version of this instrument (Collins and Read 1990a; Wilson and Costanzo 1995). The Depend and Close factors showed a large positive correlation ($r = .6863$) and Anxiety showed substantial negative correlations with Close and Depend ($r = -.3612$ and $-.5485$, respectively). These larger correlations likely result from more stringent model criteria (which reduce measurement noise) and revisions to the instrument. The

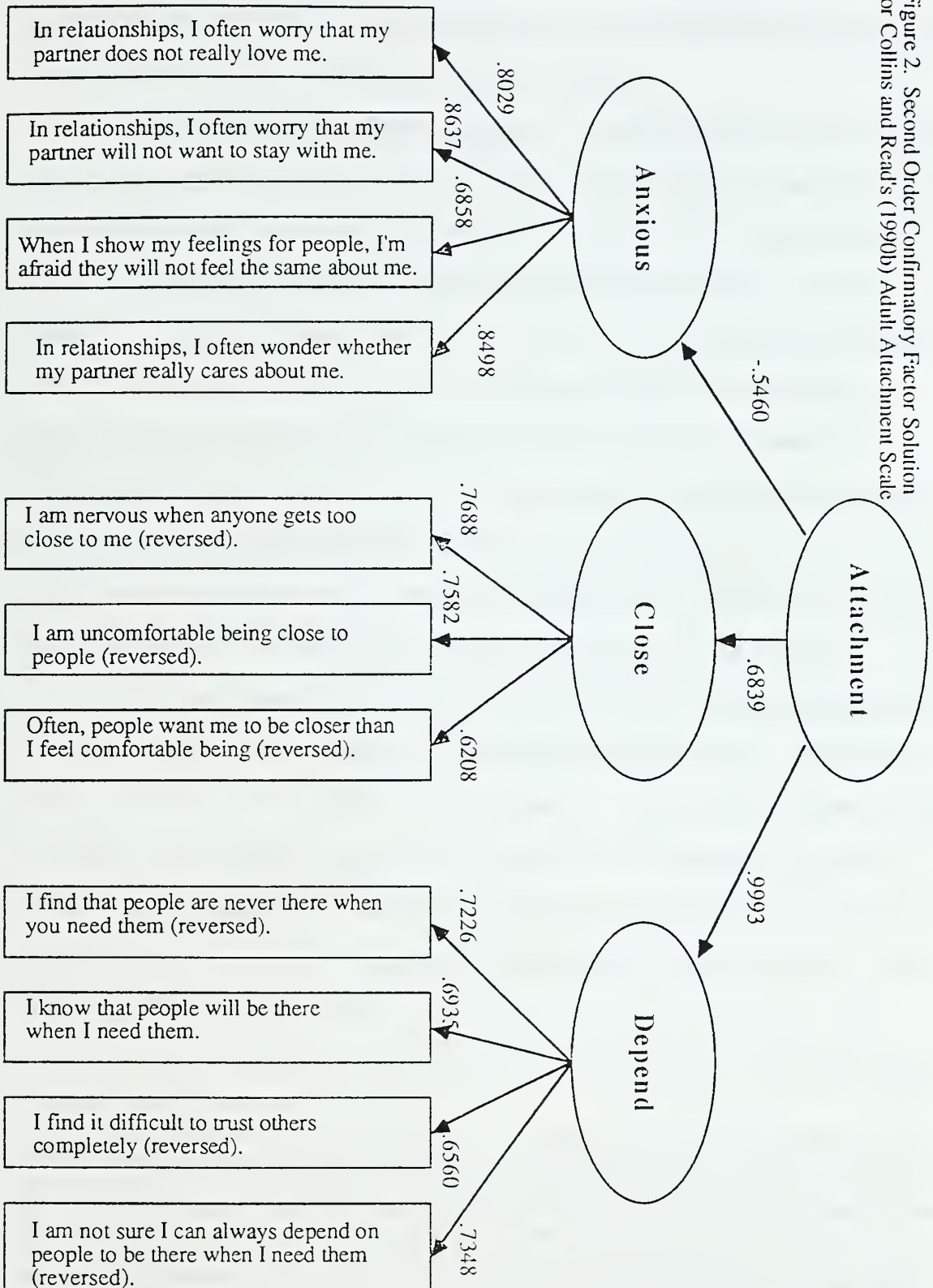
correlations also indicated significant multicollinearity that could be parsimoniously summarized with a global attachment index. Moreover, because the three factors were intended to measure aspects of interpersonal attachment, identification of a global attachment dimension was theoretically indicated.

A second order factor solution was therefore tested. Examination of the results indicated quite adequate fit indices, which were obtained by fitting the global attachment factor so as to be nearly exactly identified with the Depend dimension.¹² The resulting solution is shown in Figure 2. Goodness of fit indices were quite good: Goodness of Fit Index Adjusted for Degrees of Freedom, .9247; Bentler's Comparative Fit Index, .9615; Bentler and Bonett's Non-normed Index, .9483; Bentler and Bonett's Normed Index, .9498; Bollen's Normed Index Rho1, .9326; Bollen's Non-normed Index Delta2, .9617; root mean square residual, .0609. The global attachment dimension accounted for 46.8% of the variance in the Close factor, 29.8% of the variance in the Anxious factor, and, as expected from its near identification with the Depend factor, 99.8% of the variance in this dimension. Because identification of the superordinate attachment construct represented a

¹² This arbitrarily high association permitted the factor loading estimate for Depend on the global score to be a linear function of the other factor loadings, producing multiple possible weightings among these parameters and thus a non-unique solution. In essence, the best fitting second order solution involved two factors so closely identified that the covariance matrix no longer contained unique sets of covariances. This model is thus said to be underidentified. In order to identify the model and obtain a unique solution, it was necessary to constrain an additional parameter. This was done by presetting the factor loading for the Depend dimension on the global attachment dimension to a very high level, at .99. In the non-unique approximate solution, this loading was .9993.

The underidentification of this second order model without the additional constraint of this loading was a function of the data rather than the model per se. That is, it is entirely possible to obtain second order solutions with unique parameter estimates (several such solutions are reported later). Here, constraining an additional parameter is permissible (though not optimal) because it results in a solution that is extremely close to the approximation obtained in the original second-order solution. The task here was to develop a summary score (the second order factor) that could capture large portions of the common variance in the three first-order factors. As discussed in the text, the final model successfully summarized the covariance of the three first-order factors. Finally, the close association between the global attachment construct and the Depend factor might suggest that a single factor, first order model would be sufficient to capture the Adult Attachment scale items. However, this model in fact fit extremely poorly and was therefore rejected.

Figure 2. Second Order Confirmatory Factor Solution for Collins and Read's (1990b) Adult Attachment Scale



reasonable and parsimonious extension of the original three-factor measurement model, this second order solution was retained for subsequent analyses.

Epstein's (1983) Mother-Father-Peer Scale. No previous factor analyses have been reported for the Mother-Father-Peer Scale. Instead, the scale was constructed by retaining items that were assigned to a priori defined dimensions by 4 out of 5 judges (Epstein 1983). Here, each of the Mother, Father, and Peer subscales was factor analyzed separately. As might be expected from the lack of prior factor analyses and the relatively stringent criteria used in confirmatory factor analysis, a number of items from the questionnaire were eliminated in the final measurement models.¹³ However, the underlying factor structures hypothesized by Epstein (1983) were confirmed. For the Mother and Father subscales, factors for independence-encouragement versus overprotection, acceptance versus rejection, and idealization of the parent were identified; for the Peer subscale, a single factor of acceptance versus rejection was identified.

In all three subscales, second order solutions were theoretically meaningful and well fitting. For the Mother subscale, the second order factor represents a global index of perceived mothering. This model is shown in Figure 3. Fit indices with the current sample ($n = 666$) were acceptable: Goodness of Fit Index Adjusted for Degrees of Freedom, .9028; Bentler's Comparative Fit Index, .9375; Bentler and Bonett's Non-normed Index, .9121; Bentler and Bonett's Normed Index, .9269; Bollen's Normed Index $Rho1$, .8971; Bollen's Non-normed Index Δ^2 , .9378; root mean square residual, .0643. The equivalent factor solution for the Father subscale is shown in Figure 4. Again, fit indices

¹³ In the questionnaire itself, identically worded items were asked about maternal and paternal parenting patterns. Slightly different solutions were obtainable for the Mother and Father subscales, such that most, but not quite all, items were common to the confirmatory models for the Mother and Father subscales. These discrepancies may represent subtle but real differences in participants' conceptions of mothering and fathering. However, by comparing the initial factor solutions for the Mother and Father subscales, it was also possible to derive identical, well-fitting first order factor models for these subscales. Because these identical models represent simple measurement equivalence of the underlying factors across the mothering and fathering domains, they were retained in favor of the models with slight divergences. These identical models were selected for this study and are reported in the text.

Figure 3. Second Order Confirmatory Factor Solution for Epstein's (1983) Mother Subscales

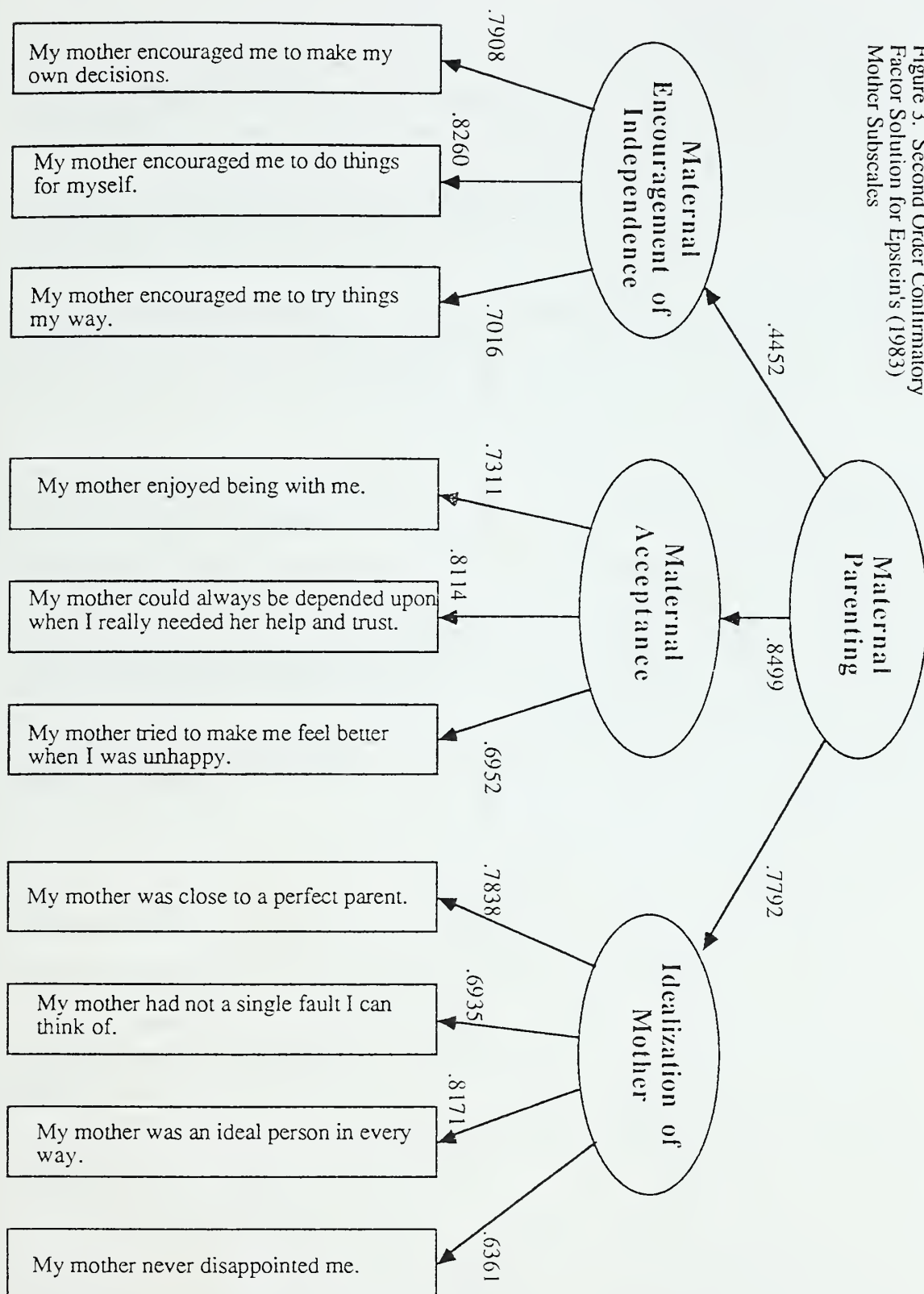
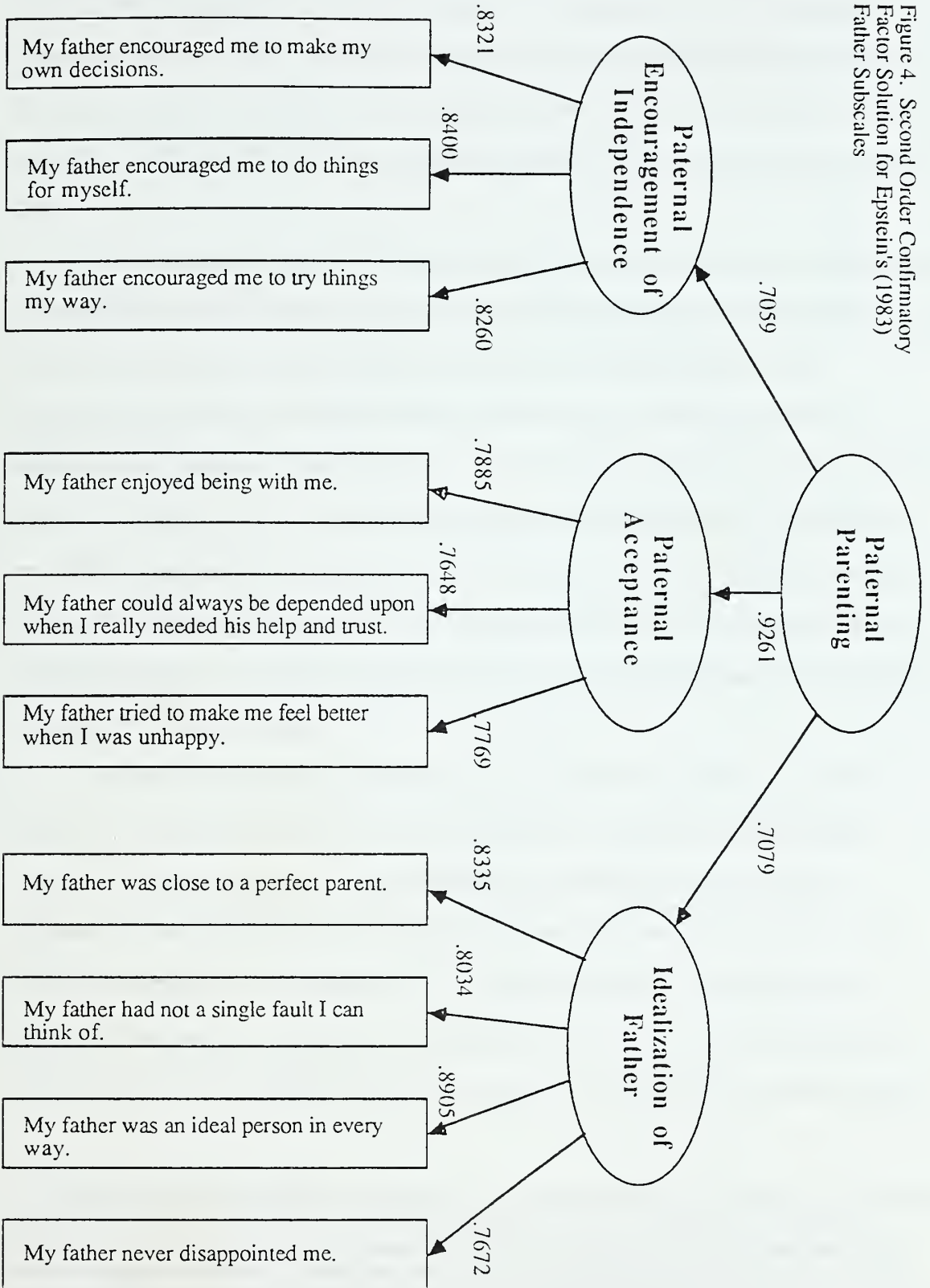


Figure 4. Second Order Confirmatory Factor Solution for Epstein's (1983) Father Subscales



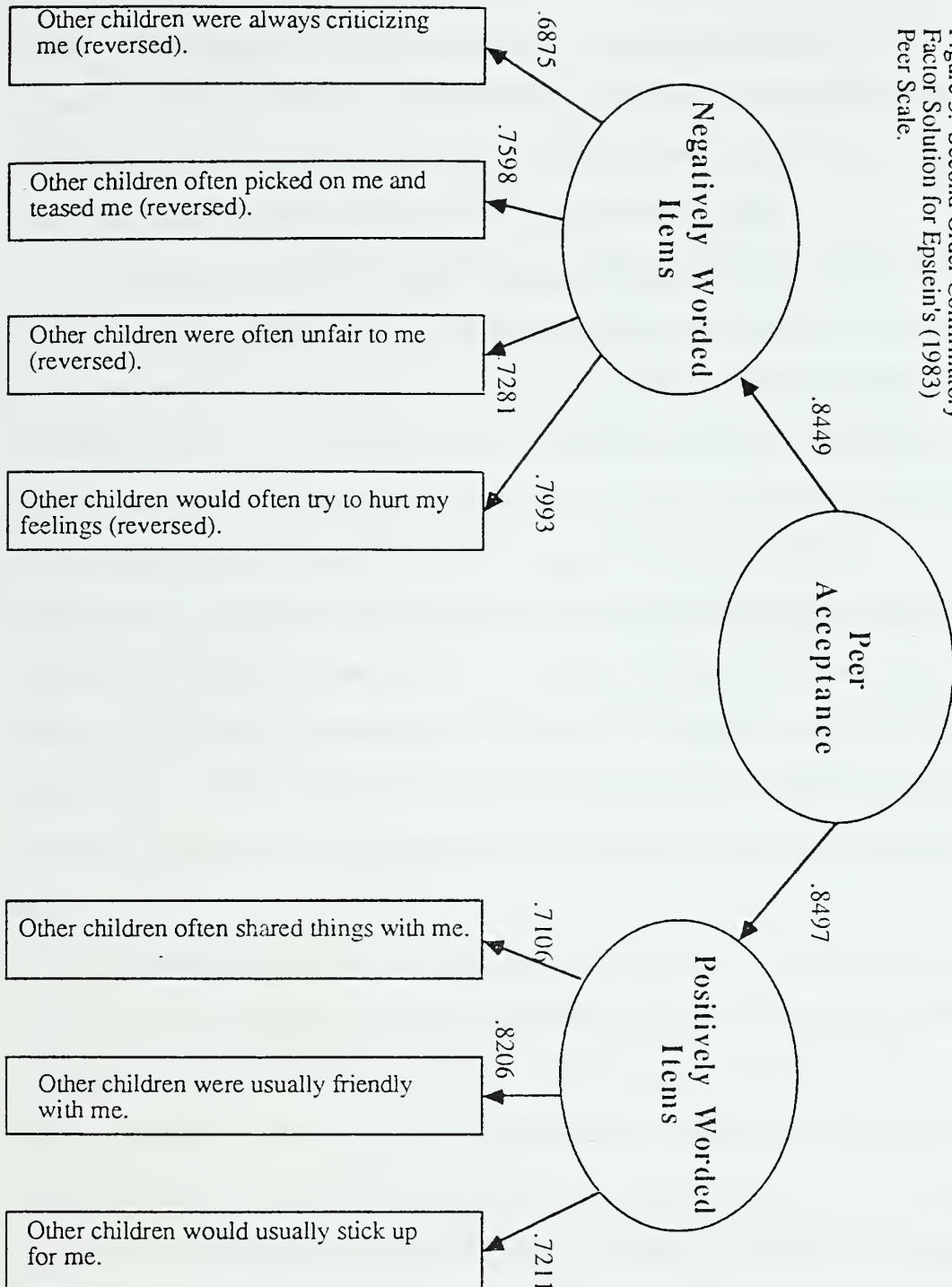
with the current sample ($n = 641$) were acceptable: Goodness of Fit Index Adjusted for Degrees of Freedom, .8972; Bentler's Comparative Fit Index, .9534; Bentler and Bonett's Non-normed Index, .9345; Bentler and Bonett's Normed Index, .9457; Bollen's Normed Index Rho1, .9326; Bollen's Non-normed Index Delta2, .9536; root mean square residual, .0755.

Interestingly, comparison of Figures 3 and 4 indicates one noteworthy difference at the second order level. The factor loading for paternal encouragement of independence was almost twice as large as that for maternal encouragement of independence. The measurement model for the Mother subscale predicted only 19.8% of the variance in maternal encouragement of independence, while the model for the Father subscale predicted fully 49.8% of the variance in paternal encouragement of independence. This difference may indicate that participants' conceptions of their mothers were more differentiated than those of their fathers, and in particular that maternal encouragement of independence was distinguished from the other two maternal factors to a greater degree than was the case for the analogous paternal factors.

For the Peer subscale, a second order factor solution was required in order to identify the hypothesized dimension of peer acceptance. Conceptually similar items factored into positively and negatively worded groups, indicating that participants responded differentially depending simply on the phrasing of the item. However, these two factors were highly correlated ($r = .79$). In order to account for this differential responding and obtain a conceptually meaningful factor solution, a second order factor solution was fit.¹⁴ The solution is shown in Figure 5. Fit indices were excellent for the

¹⁴ Differential responding depending upon whether the questionnaire item is worded positively or negatively is more common than not and can be conceptualized as method variance. Because reverse scoring of negatively worded items often does not eliminate the effect, accounting for such method variance through hierarchical factor solutions is frequently required. Although I report two factor solutions that fit well despite a mixture of positively and negatively worded items loading on the same factor (see the solutions for the Adult Attachment Scale, Figure 2, and the Intrinsic Motivation Index, Figure 7), the remaining

Figure 5. Second Order Confirmatory Factor Solution for Epstein's (1983) Peer Scale.



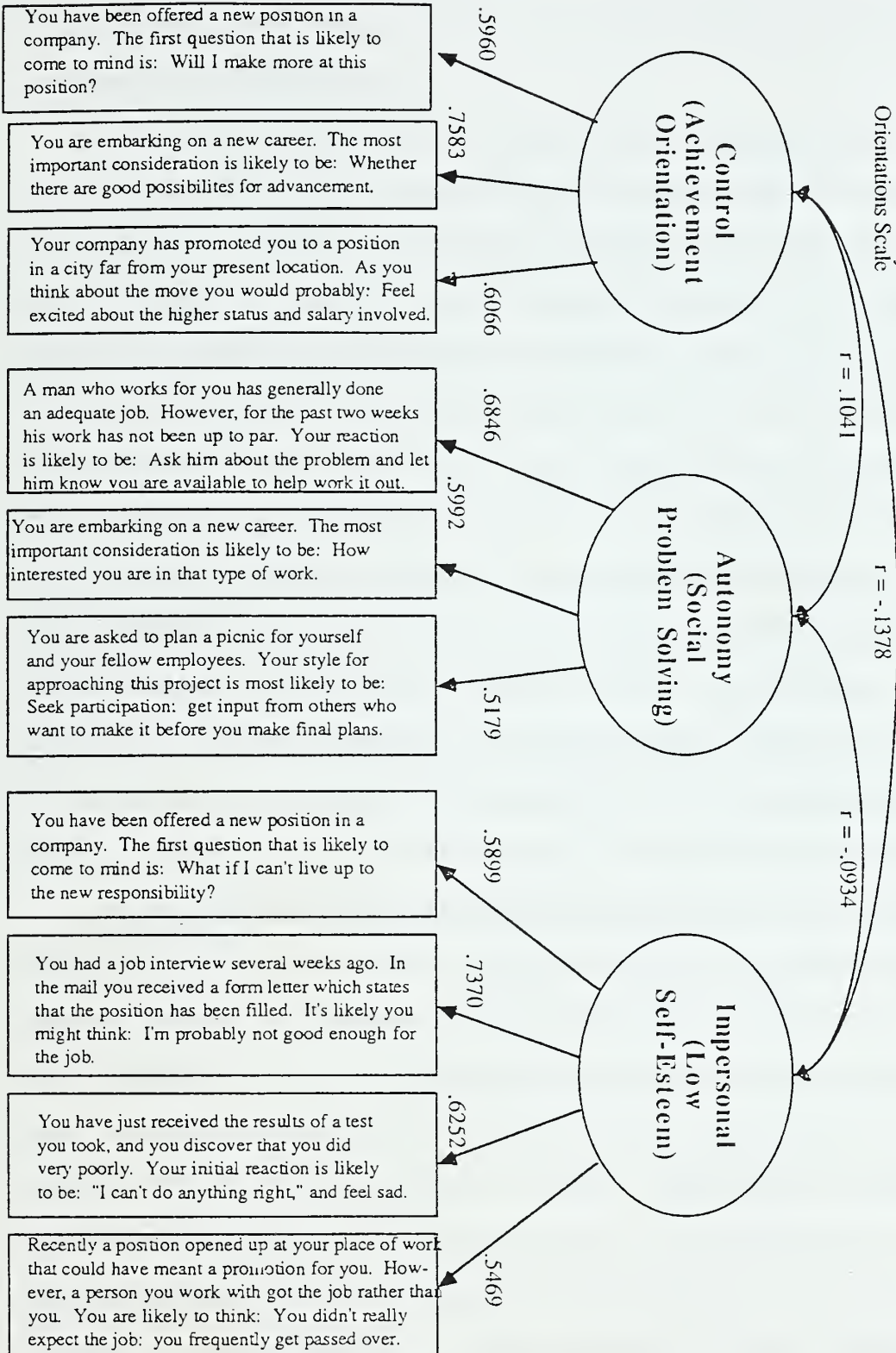
solutions contain either purely positively or purely negatively worded items. Attempts to fit hierarchical factor solutions in these models to account for the phrasing of the items were not successful, and instead items were simply eliminated until an optimal single-tier factor solution could be obtained.

current sample ($n = 649$): Goodness of Fit Index Adjusted for Degrees of Freedom, .9361; Bentler's Comparative Fit Index, .9725; Bentler and Bonett's Non-normed Index, .9572; Bentler and Bonett's Normed Index, .9652; Bollen's Normed Index Rho1, .9452; Bollen's Non-normed Index Delta2, .9726; root mean square residual, .0309.

Deci and Ryan's (1985b) General Causality Orientations Scale. Deci and Ryan's (1985b) description of prior factor analysis indicates that several items were rewritten after factor analysis, and that the original factor analysis included a pool of 96 items answered by 200 participants. These conditions are not optimal for obtaining replicable factor solutions, and in the current sample ($n = 626$) many of the final 36 items selected by Deci and Ryan did not satisfy measurement criteria for inclusion in the final model. Nevertheless, a three-factor solution approximating that of Deci and Ryan (1985b) was identified with excellent fit characteristics: Goodness of Fit Index Adjusted for Degrees of Freedom, .9786; Bentler's Comparative Fit Index, .9916; Bentler and Bonett's Non-normed Index, .9883; Bentler and Bonett's Normed Index, .9614; Bollen's Normed Index Rho1, .9457; Bollen's Non-normed Index Delta2, .9918; root mean square residual, .0336.

The final solution is shown in Figure 6. As indicated by the parenthetical labels for the latent factors, the measurement model identified with the current sample is perhaps best characterized as an *approximate* confirmation of the theoretical constructs posited by Deci and Ryan (1985b). Examination of the individual items loading on the three factors indicates that the control orientation is entirely contextualized within a career achievement framework. The autonomy orientation is largely weighted towards social problem solving, and again is contextualized within career achievement. The impersonal orientation is represented by items reflecting performance anxiety and low self-esteem, again primarily in the context of career achievement. The elimination of many low-loading items resulted in

Figure 6. Confirmatory Factor Solution
for Deci and Ryan's (1985b)
General Causality
Orientations Scale



latent factors that, while theoretically connected to causality orientation, may need to be conceptualized more parsimoniously.

Reinterpretation of the meaning of the latent factors is perhaps most apt for the control orientation factor, which is represented solely by monetary and status aspects of career advancement. Differences in interfactor correlations also indicate reinterpretation is in order. Because control and impersonal orientations both represent a lack of intrinsic motivation, it would be reasonable for them to be positively correlated. Deci and Ryan (1985b) found such a correlation with observed scale scores ($r = .273$), while I found a negative correlation with latent factors ($r = -.1378$). Similarly, Deci and Ryan (1985b) report a modest negative correlation between autonomy and impersonal orientation ($r = -.248$), while the correlation here with latent factors was considerably smaller ($r = -.0934$). Finally, while Deci and Ryan found control and autonomy to be unrelated, they were positively correlated in the current factor solution ($r = .1041$). These structural discrepancies, together with examination of the final factor items, suggest that the meaning of the latent factors may be closer to the parenthetical labels than the original Deci and Ryan constructs. I interpreted findings with these factors in subsequent analyses accordingly.

Deci and Ryan's (unpublished) Intrinsic Motivation Inventory. Clear confirmation of Deci and Ryan's (unpublished) factor structure for the post-experimental Intrinsic Motivation Inventory was obtained in a first-order solution after eliminating low-loading items. Interafactor correlations in this model were consistent with intrinsic motivation theory: participants' subjective sense of competence, interest and enjoyment, effort, and choice about the DS-CPT were all positively correlated. Most notable in this regard was a large correlation between participants' perception of how much choice they had in completing the DS-CPT and their interest/enjoyment in the task ($r = .51$). In contrast, participants' experience of pressure and tension was negatively correlated with their sense

of choice, interest and enjoyment, and competence. Finally, a small positive relationship between pressure-tension and participants' effort emerged.

Because these factors could all be considered facets of a global level of intrinsic motivation, a second-order solution was also appropriate. When tested, it fit reasonably well, given its complexity, the relatively small number of high-loading items per factor, and the smaller number of participants completing this instrument (183 completed all questions on the inventory): Goodness of Fit Index Adjusted for Degrees of Freedom, .8714; Bentler's Comparative Fit Index, .9619; Bentler and Bonett's Non-normed Index, .9538; Bentler and Bonett's Normed Index, .9024; Bollen's Normed Index Rho1, .8817; Bollen's Non-normed Index Delta2, .9624; root mean square residual, .1623.¹⁵

The final model is shown in Figure 7. As can be seen, all factor loadings were substantial, and the content of the items loading on the latent variables is consistent with the constructs as originally posited by Deci and Ryan. The single exception to this confirmation was the effort-importance factor; no items indicating participants' rating of the DS-CPT's importance loaded on this factor. As a result, the underlying construct was simply labelled "effort."

Emotion Scale. Finally, a second order confirmatory factor model for the post-experimental emotion self-report instrument was developed and is shown in Figure 8. First order factors for positive emotion, angry (or active negative) emotion, and fearful/sad (or passive negative) emotion were identified, together with a superordinate factor indicative of global emotionality. Goodness of fit indices for this smaller sample ($n = 190$) were all quite good: Goodness of Fit Index Adjusted for Degrees of Freedom, .9280; Bentler's

¹⁵ As indicated earlier, root mean square residuals close to 0 are indicative of well-fitting models. The larger residual reported here indicates that a greater percentage of the covariance matrix than is desirable was not accounted for by the confirmatory model. Because most of the other fit indices are acceptable or better, and because all components of the model appeared to fit extremely well, it may be that sample size was responsible for this larger root mean square residual. For a given factor solution, residuals will be larger for smaller sample sizes (Bollen 1989). By current structural equation standards, a sample of 183 is small and therefore may have contributed to the larger root mean square residual reported here.

Figure 7. Second-Order Confirmatory Factor Solution for Deci and Ryan's (unpublished) Intrinsic Motivation Inventory

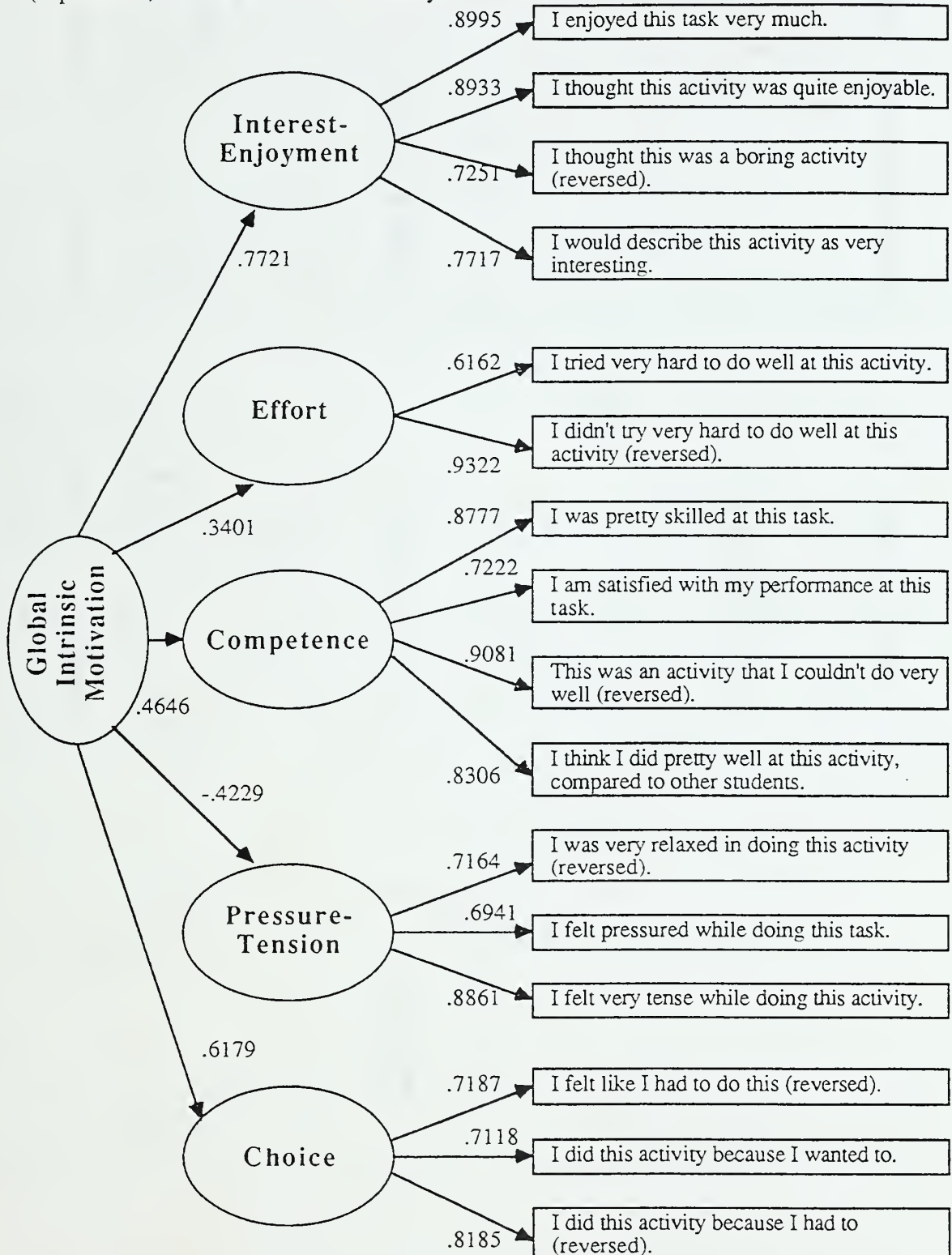
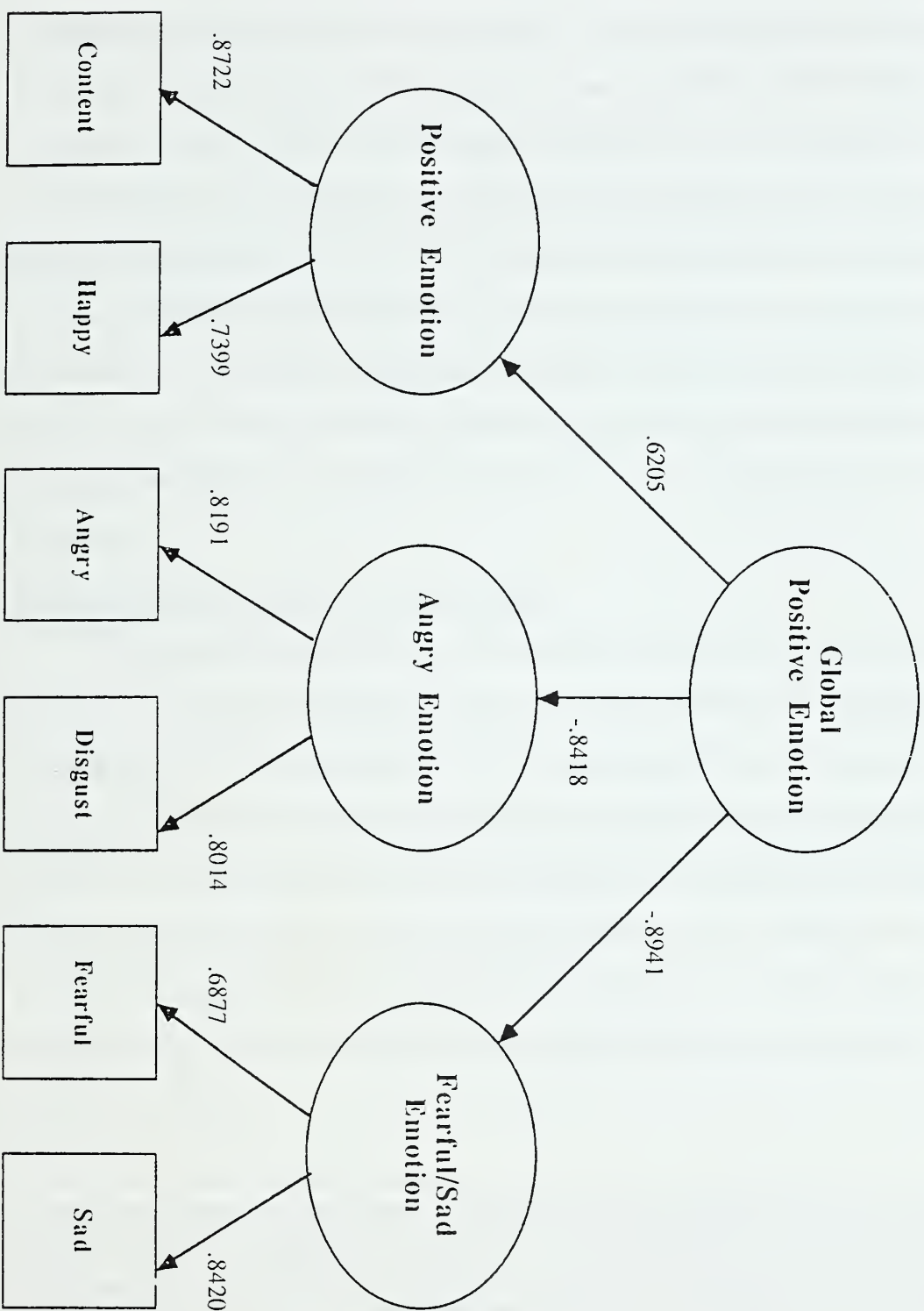


Figure 8. Second Order Confirmatory Factor Solution for Emotion Instrument



Comparative Fit Index, .9857; Bentler and Bonett's Non-normed Index, .9644; Bentler and Bonett's Normed Index, .9722; Bollen's Normed Index Rho1, .9305; Bollen's Non-normed Index Delta2, .9860; root mean square residual, .0794. This straightforward model provided global summaries that measured emotion broadly, and was therefore retained for subsequent analyses in which summary scores were preferable over multiple individual indicators. However, because a number of potentially interesting emotions did not contribute to this model (embarrassment, tension, contemptuousness, amusement, and arousal), when sufficient power was available, subsequent analyses were conducted both with the more global emotion factors identified here and with the indicators of individual emotions.

Step 2: Classical Attachment Style Relationships

To explore the classical division of attachment into secure, anxious, and avoidant styles, scores on the instruments described above and the DS-CPT were compared across the three groups. Following earlier work (Collins and Read 1990a; Wilson and Costanzo 1995), the trichotomous division of attachment was measured first by Hazan and Shaver's (1987) forced choice instrument, and second by agglomerating participants into three groups using cluster analysis (Ward's minimum-variance method, with squared Euclidean distances) conducted on Adult Attachment Scale factor scores.¹⁶ The first technique assumes a priori the existence of three discrete attachment styles, while the second technique attempts to derive these styles empirically, from the pattern of participants'

¹⁶ Cluster analysis is an exploratory, agglomerative hierarchical technique that attempts to derive empirically the existence of discrete groups of participants based upon patterns of responding across several measures. Although a vast number of clustering methods exist, I employed Ward's minimum-variance method in keeping with methods used in prior work. This method starts with each participant in her own cluster, and then, one step at a time, successively joins clusters that are most similar to each other along the clustering dimensions, until all clusters have been joined into a single cluster. At each clustering step this method maximizes between-cluster differences while minimizing within-cluster variability, and indices for inter-cluster and intra-cluster variability are provided for each step. An optimal cluster solution is then selected by examining the sequence of these indices and identifying a clustering step that is characterized by small within-cluster variance and large between-cluster variance, and that is followed by a clustering step showing a large increase in within-cluster variance (Aldenderfer and Blashfield 1990; SAS Institute 1990).

responses to the Adult Attachment Scale. These methods were employed in order to replicate prior research. However, while prior research used observed scale scores both in the clustering procedure and in subsequent between-group analyses, in the current analyses factor scores were employed for both purposes.¹⁷ Because they yielded similar results, across-group comparisons using the a priori Hazan and Shaver (1987) groupings and the cluster solution are presented simultaneously.

First, results of the cluster analysis performed on participants' Adult Attachment factor scores yielded some evidence for a three-cluster solution, as expected. When the three clusters were agglomerated into two, a sizeable jump in within-cluster variability was observed (pseudo η^2 for three-cluster solution, 185.0; for two-cluster solution, 310.6). Additionally, between-cluster variability increased from the four-cluster level (pseudo $\bar{E}$ = 439.3) to the three-cluster level (pseudo $\bar{E}$ = 509.6), indicating better separation of clusters at the three- than at the four-cluster solution. On the basis of these data, I chose to retain the three-cluster solution for analyses.¹⁸

¹⁷ The advantage of factor scores over observed scores in terms of measurement error has already been noted (see Footnote 5). In addition, because Ward's method of clustering employs squared Euclidean distances as measures of similarity across and within clusters, standardized clustering variables are often recommended; variables with relatively larger variances tend to have greater effects on the resulting clusters than those with smaller variances (Aldenderfer and Blashfield 1984; SAS Institute 1990). Using factor scores, which are normally distributed and tend to have very similar variances, can avoid unintended biasing from unequally weighted variables. However, there remains considerable controversy regarding the appropriateness of standardizing scores prior to cluster analysis. In particular, Aldenderfer and Blashfield (1984) observe that factor analysis may blur the relationship between clusters, because modes present in the data are merged in order to obtain normally distributed factor scores. Results from the cluster analysis, reported below, are strongly suggestive of such effects. However, a parallel cluster analysis using unstandardized, observed scores rather than factor scores for the Depend, Close and Anxiety subscales produced results that were very similar to those reported in text.

¹⁸ However, there was also evidence for a two-cluster solution, which showed still greater between-cluster separation (pseudo $\bar{E}$ = 606.1) and approximately half the within cluster variability shown in a single cluster solution (pseudo η^2 = 310.6 versus 606.1). The two-cluster solution resulted from a merging of Clusters 1 and 2 from the three-cluster solution described below; examination of group means for the two-cluster solution indicated that participants were aggregated into two broad groups of secure and insecure attachment.

In addition, although the agglomerative coefficients did not fully support a four-cluster solution, this solution was also examined. The four-cluster solution was obtained by breaking the avoidant cluster into two groups, one with high levels of Anxious and slightly above average levels of Close and Depend scores, the other with low Anxious and slightly below average levels of Close and Depend scores. These categories

There were no sex differences in attachment style assessed either by Hazan and Shaver's (1987) instrument (chi square (2, $N = 624$) = 1.349, $p > .5$) or by cluster (chi square (2, $N = 636$) = .53, $p > .75$). This finding is consistent with prior research with these instruments and indicated that it was not necessary to control for gender in making between-group comparisons. Proportions of participants self-classifying as secure (66.1%), avoidant (26.0%), and anxious (7.9%) were similar to the ratios found in previous studies (Collins and Read 1990; Feeney and Noller 1990; Hazan and Shaver 1987, 1990; Wilson and Costanzo 1995). The distribution of self-classified anxious, avoidant, and secure participants among the three clusters was highly significant, chi square (4, $N = 662$) = 196.63, $p < .000$, phi coefficient = .545.¹⁹ All but 9% of Cluster 1 was comprised of individuals who classified themselves as secure, suggesting a naturally occurring category of secure attachment. Clusters 2 and 3 each comprised mixes of anxious and avoidant individuals. Cluster 2 showed a somewhat greater predominance of self-classified avoidant participants, while self-classified anxious participants were most likely to be found in Cluster 3. These patterns suggested that the cluster solution had yielded a rough approximation to the classical trichotomy of attachment styles.²⁰

may correspond to the fearful-avoidant and dismissive-avoidant attachment styles proposed by Bartholomew and Horowitz (1991). The ambiguity in identifying the proper cluster solution here is consistent with recent work in the adult attachment field, which indicates that insecure and secure attachment styles are robustly distinguishable from each other, but that subtypes of insecure attachment are less clearly differentiated from one another (Feeney, Noller, and Hanrahan 1994). See, however, footnotes 17 and 20 for potential methodological contributions to the ambiguity of the cluster solution.

¹⁹ The phi coefficient indicates the degree of contingency between categorical variables and is analogous to Pearson's r for continuous variables.

²⁰ Alternatively, examination of means for the Adult Attachment Scale factor scores (reported below) also suggested that Cluster 3 could be straightforwardly characterized as the group with the most negative attachment scores; Cluster 2, as the group with average attachment scores; and Cluster 1, as the group with the most positive attachment scores. This partitioning of participants may be due to the use of normalized factor scores as clustering variables, because normalizing variables may blur observed modes that mark naturally occurring group boundaries. Thus, the three clusters may simply represent the upper, middle, and lower thirds of a multivariate distribution. This solution is also more likely when using Ward's minimum-variance method of clustering, because this method of aggregation is strongly biased to produce groups of equal size (Aldenderfer and Blashfield 1984; SAS Institute 1990). However, as noted above (footnote 16), the three-cluster solution using unstandardized, observed data rather than factor scores produced similar results. Moreover, the patterns of means shown across clusters formed using factor scores broadly paralleled

Table 1 displays significant between-group comparisons for the entire sample, segregating participants by self-classification on the Hazan and Shaver (1987) attachment instrument; Table 2 displays these results by cluster. Where second order factor solutions were identified, both first and second order factors are compared across groups. In each table, group means for the Adult Attachment Scale factor scores are shown first. These are followed by group means for the Mother-Father-Peer factor scores, for Venables et al.'s (1990) schizotypy factor scores, and finally for Deci and Ryan's (1985b) General Causality Orientations factor scores. Each of these sets of comparisons is described in sequence below, followed by group comparisons for the DS-CPT and post-experimental measures.

Adult Attachment Scale factor scores. As expected, the three attachment styles were associated with significantly different Adult Attachment Scale factor scores. Securely attached participants, whether grouped by the Hazan and Shaver paragraph or by cluster analysis, showed higher Close and Depend and lower Anxious scores than the insecure attachment groups. Anxiously attached participants showed higher Anxious scores than the other groups regardless of grouping method. In the comparisons using self-classification groupings (Table 1), these participants had lowered Close and Depend scores, but not as low as those shown by avoidantly attached participants; in the comparisons using clusters (Table 2), these participants had markedly lower Close and Depend scores. Avoidantly attached participants had somewhat elevated Anxious scores and quite low Close and Depend scores in comparisons using self-classification (Table 1); in the comparisons using clusters, these participants had higher Close and Depend scores than those for the anxious cluster, but these scores were still significantly lower than those for the secure cluster.

those across the self-classification categories formed from Hazan and Shaver's (1987) measure. Given these findings and the recent evidence that avoidant and anxious attachment are not mutually exclusive in adulthood (Feeney, Noller, and Hanrahan 1994), I retained the triad of secure, anxious, and avoidant attachment categories as highly approximate labels for the clusters. In the analyses that follow, however, it must be borne in mind that the clusters probably reflect methodological artifact as well as real-life admixtures of attachment styles.

Table 1. Group Means for Anxious, Avoidant, and Secure Attachment as Assessed by Self-Classification on Hazan and Shaver's (1987) Instrument

Factor	Secure $\underline{n} = 446$ (66.1%)	Anxious $\underline{n} = 53$ (7.9%)	Avoidant $\underline{n} = 175$ (26.0%)	F	r^2
Adult Attachment Scale Factors					
Anxious	-.2923 _a	1.1998 _b	.3275 _c	95.10***	.224
Close	.3733 _a	-.1439 _b	-.9155 _c	204.59***	.383
Depend	.3684 _a	-.6750 _b	-.7017 _b	145.53***	.306
Global Attachment	.3675 _a	-.6732 _b	-.7000 _b	144.83***	.305
Mother-Father-Peer Factors					
Maternal Encouragement of Independence	.1001 _a	-.0111 _{ab}	-.2489 _b	7.03**	.023
Maternal Acceptance	.1608 _a	-.3844 _b	-.2967 _b	17.66***	.056
Idealization of Mother	.0759	-.2454	-.1154	2.81, ns	--
Global Maternal Parenting	.1290 _a	-.3477 _b	-.2258 _b	15.62***	.047
Paternal Encouragement of Independence	.1236 _a	-.4092 _b	-.2017 _b	10.72***	.035
Paternal Acceptance	.1493 _a	-.5074 _b	-.2148 _b	16.03***	.051
Idealization of Father	.0817 _a	-.2798 _b	-.1300 _b	4.54*	.015
Global Paternal Parenting	.1398 _a	-.4736 _b	-.2068 _b	16.89***	.052
Peer Acceptance	.1523 _a	-.7383 _b	-.1603 _c	24.98***	.077

(Table 1 continued on following page)

Table 1 (continued). Group Means for Anxious, Avoidant, and Secure Attachment as Assessed by Self-Classification on Hazan and Shaver's (1987) Instrument

Factor	Secure $\underline{n} = 446$ (66.1%)	Anxious $\underline{n} = 53$ (7.9%)	Avoidant $\underline{n} = 175$ (26.0%)	F	r^2
Schizotypy Factors					
Schizophrenism	-.1297 _a	.4309 _b	.2194 _b	17.87***	.052
Anhedonia	-.0514	.0801	.1275	2.88, ns	--
Causality Orientation Factors					
Control (Achievement)	.0048	-.0533	-.0045	0.09, ns	--
Autonomy (Social Problem Solving)	.0486 _a	.0433 _{ab}	-.1393 _b	3.18*	.010
Impersonal (Low Self-Esteem)	-.1385 _a	.3671 _b	.2196 _b	15.01***	.048

Note: Degrees of freedom for the F tests varied from (2, 598) to (2, 659) depending on missing values. Means with different subscripts differ significantly across rows according to Tukey tests.

* $p < .05$ ** $p < .001$ *** $p < .0001$

Table 2. Group Means for Anxious, Avoidant, and Secure Attachment as Grouped by Cluster Analysis

Factor	Cluster 1 (Secure) $\underline{n} = 254$ (36.9%)	Cluster 3 (Anxious) $\underline{n} = 173$ (25.1%)	Cluster 2 (Avoidant) $\underline{n} = 262$ (38.0%)	F	r^2
Adult Attachment Scale Factors					
Anxious	-.7983 _a	1.0648 _b	.0708 _c	480.29***	.583
Close	.6522 _a	-1.0039 _b	.0307 _c	360.72***	.512
Depend	.7873 _a	-1.1775 _b	.0143 _c	782.76***	.695
Global Attachment	.7854 _a	-1.1751 _b	.0144 _c	775.58***	.693
Mother-Father-Peer Factors					
Maternal Encouragement of Independence	.1925 _a	-.2878 _b	-.0030 _c	13.25***	.039
Maternal Acceptance	.2123 _a	-.3484 _b	.0103 _c	18.49***	.054
Idealization of Mother	.0701	-.1400	.0185	1.85, ns	--
Global Maternal Parenting	.1784 _a	-.2607 _b	-.0115 _c	13.64***	.039
Paternal Encouragement of Independence	.2425 _a	-.3678 _b	-.0033 _c	20.81***	.062
Paternal Acceptance	.2675 _a	-.4002 _b	-.0138 _c	26.43***	.077
Idealization of Father	.1906 _a	-.2482 _b	-.0389 _b	10.48***	.032
Global Paternal Parenting	.3884 _a	-.3850 _b	-.0166 _c	26.28***	.077
Peer Acceptance	.2911 _a	-.4349 _b	-.0131 _c	36.43***	.102

(Table 2 continued on following page)

Table 2 (continued). Group Means for Anxious, Avoidant, and Secure Attachment as Grouped by Cluster Analysis

Factor	Cluster 1 (Secure) $\underline{n} = 254$ (36.9%)	Cluster 3 (Anxious) $\underline{n} = 173$ (25.1%)	Cluster 2 (Avoidant) $\underline{n} = 262$ (38.0%)	$\underline{F}$	r^2
Schizotypy Factors					
Schizophrenism	-.3580 _a	.4557 _b	.0598 _c	53.99***	.139
Anhedonia	-.1141 _a	.0994 _b	.0347 _{ab}	3.57*	.011
Causality Orientation Factors					
Control (Achievement)	.0534	-.0012	-.0537	0.93, ns	--
Autonomy (Social Problem Solving)	.1352 _a	-.1731 _b	-.0216 _{ab}	7.06**	.022
Impersonal (Low Self-Esteem)	-.3157 _a	.3855 _b	.0592 _c	35.07***	.102

Note: Degrees of freedom for the $\underline{F}$ tests varied from (2, 598) to (2, 659) depending on missing values. Means with different subscripts differ significantly across rows according to Tukey tests.

* $p < .05$ ** $p < .001$ *** $p < .0001$

Note that the pattern for the global attachment dimension closely follows that for the Depend factor, in keeping with the very close association between these variables developed in the second order factor solution. There were no sex differences among these factor scores (p values $> .9$)

Although there is evidence of admixture of attachment styles in the cluster solution, and hence some ambiguity in group means, these findings are broadly consistent with prior research (Collins and Read 1990a; Wilson and Costanzo 1995). The pattern of means indicates that secure attachment is characterized by an absence of anxiety about abandonment and reciprocity, confidence in the dependability of others, and comfort with interpersonal closeness. Anxious attachment is characterized by higher anxiety about abandonment and reciprocity, less confidence in the dependability of others, and less ease with interpersonal closeness. Finally, avoidant attachment is characterized by moderate levels of anxiety about abandonment and reciprocity, less confidence in the dependability of others, and less ease with interpersonal closeness.

The magnitudes of these effects (approximated by the $\bar{r}^2$ values in the final columns of the tables) are substantial but should be taken in context. With respect to Table 1, the Adult Attachment Scale was constructed from Hazan and Shaver's (1987) instrument, and the large between-group differences therefore may be partly due to methodological overlap. With respect to Table 2, the clusters were formed by maximizing differences along the three first-order attachment dimensions, so the large $\bar{r}^2$ values serve only to indicate that good between-cluster separation was achieved in the three-cluster solution.

Mother-Father-Peer Scale factor scores. With little exception, results of between-group comparisons along the factors developed from Epstein's (1983) scale are what one would expect and are relatively consistent across grouping method. Securely attached participants report higher encouragement of independence and acceptance from both mother and father than either of the insecurely attached groups (although the comparison between

anxious and secure groups in Table 1 does not quite attain significance for maternal encouragement of independence). Factor scores for idealization of mother did not differ across attachment style. After correcting the alpha level for multiple comparisons, there was a trend for secure participants to report marginally higher levels of paternal idealization. Global parenting factor scores, which summarize the three first-order factors for each parent, show consistent results across mother and father and across grouping method: secure attachment is associated with positive global parenting scores, while both anxious and avoidant attachment are associated with negative global parenting scores. Finally, the three groups also differed in the expected directions in their reports of childhood peer acceptance, with securely attached participants showing positive peer acceptance scores, and avoidantly and anxiously attached participants showing negative peer acceptance scores.²¹

Schizotypy factors. The patterns for positive schizotypy -- the schizophrenia factor scores -- are similar to prior findings (Wilson and Costanzo 1995). Securely attached individuals reported less schizophrenia, while anxiously and avoidantly attached individuals reported higher levels. The magnitude of this effect in both the self-classification and cluster comparisons is also comparable to prior findings. For the anhedonia factor score, I found a small but significant effect only for the cluster comparisons, with securely attached participants reporting somewhat lower anhedonia. This finding stands in contrast to prior findings of 6-14% of the variance in anhedonia being accounted for by categorical attachment style (Wilson and Costanzo 1995).

There was no sex effect for schizophrenia ($p > .2$), replicating prior findings (Wilson and Costanzo 1995; see also nearly identical results using the Perceptual

²¹ There were two small sex effects for these factors: compared to males, females reported greater maternal encouragement of independence ($M = .1076$ versus $-.1321$; $F(1, 616) = 10.21$, $p < .0015$, $r^2 = .016$) and slightly less idealization of their fathers ($M = -.0866$ versus $.0856$; $F(1, 595) = 4.87$, $p < .0276$, $r^2 = .008$).

Aberration and Magical Ideation Scales, Chapman and Chapman 1989b). However, females reported less anhedonia than males ($M = -.2195$ versus $.2460$, respectively; $F(1, 629) = 50.17$, $p < .0001$, $\eta^2 = .074$). This effect contrasts with prior findings of no sex effects for this dimension (Wilson and Costanzo 1995), but is consistent with sex differences reported by Chapman and Chapman (1989b) for both physical and social anhedonia.

General Causality Orientation factors. Mixed results emerged for the three factors derived from Deci and Ryan's (1985b) measure. No effect for attachment style was found for the Control (achievement orientation) factor score. A marginal effect for attachment style was found for the Autonomy (social problem solving) factor score, such that secure attachment was associated with marginally higher scores than was insecure attachment. For the Impersonal (low self-esteem) factor, however, a sizeable difference between attachment groups emerged in the expected direction. Securely attached individuals had much lower scores (i.e., higher self-esteem) than the two insecure attachment groups. Anxiously attached participants reported the lowest self-esteem, although the contrast with avoidant participants only became significant in comparisons across clusters.²²

DS-CPT Performance. Although prediction of DS-CPT performance was conducted primarily in the context of growth curve modelling, a preliminary check on the independence of attachment and attention was conducted by comparing attachment groups' DS-CPT performance. For these analyses, four DS-CPT summary scores were used:

²² The pattern of sex differences for these factors supports the interpretation of the underlying dimensions as low self-esteem and social problem solving, rather than as impersonal and autonomous causality orientations. Females reported both greater social problem solving than males ($M = .0690$ versus $-.0841$; $F(1, 585) = 5.85$, $p < .02$) and lower self-esteem ($M = .1974$ versus $-.2214$; $F(1, 585) = 37.01$, $p < .0001$). These findings are consistent with gender stereotypes and prior research (see Fredrickson and Roberts 1994). There was no sex difference in achievement orientation. Although it is possible that females had both more autonomy and more impersonal causality orientations than males, such an interpretation is not consistent with any prior research, to my knowledge.

overall hit rate, false alarm rate, response bias (B''), and perceptual sensitivity (A').²³ In addition, the decrease in perceptual sensitivity over time (a standard index of vigilance) was computed as the simple difference between perceptual sensitivity scores on the first and last blocks of the DS-CPT. As expected, no differences in DS-CPT performance were found in comparing any of these summary scores across the attachment groups formed either via self-classification (Wilks' Lambda exact $F(10, 364) = 1.4464, p > .15$) or via cluster analysis (Wilks' Lambda exact $F(10, 364) = .6029, p > .8$).²⁴ There were also no sex differences for these summary scores (Wilks' Lambda exact $F(5, 185) = 1.3104, p > .26$).

Post-experimental measures. There were no attachment style differences in any of the first-order Intrinsic Motivation Index factor scores (for the self-classification groups, Wilks' Lambda exact $F(10, 348) = 1.1839, p > .3$; for the clusters, Wilks' Lambda exact $F(10, 348) = .4412, p > .9$) or the global second order intrinsic motivation factor (for the self-classification groups, $F(2, 178) = 2.12, p > .12$; for the clusters, $F(2, 178) = .37, p > .69$). There were also no attachment style differences for the measure of effort indexed by persistence at the hand-held dynamometer task (for the self-classification groups, $F(2, 186) = .09, p > .9$; for the clusters, $F(2, 186) = 1.33, p > .26$). Finally, there were no attachment style differences for the individual emotion items (for the self-classification groups, Wilks' Lambda exact $F(22, 350) = 1.2858, p > .17$; for the clusters, Wilks' Lambda exact $F(22, 350) = 1.4035, p > .11$). However, the MANOVA results for the individual emotion items were suggestive of a trend, and a more powerful test using the

²³ Values for A' were negatively skewed and exhibited large kurtosis. Following Nuechterlein's (1991) recommendation, A' scores were transformed using the formula $2 \arcsin \sqrt{A'}$. The resulting transformed scores were very highly correlated with the original A' scores (ranging from .9679 to .9786) but had greatly reduced skewness and kurtosis. These transformed scores were used throughout all analyses involving perceptual sensitivity.

²⁴ Although there was no main effect for attachment style on DS-CPT performance, it was conceivable that attachment might interact with motivational condition to influence attentional performance (e.g., securely attached participants might be less likely to become anxious or unmotivated in the low autonomy condition). MANOVA tests for these interactions were clearly nonsignificant ($p > .46$ for the self-classification groups and $p > .95$ for the clusters).

global second-order emotion factor yielded results for the clusters that, after correcting alpha for multiple comparisons, was marginally significant ($F(2, 185) = 3.32, p < .0382$). This comparison was not significant across the self-classification groups ($F(2, 185) = 1.25, p > .29$).²⁵ For the between-cluster differences that came close to reaching significance, these findings indicated that individuals in the securely attached cluster reported more positive emotion than did those in the avoidantly and anxiously attached clusters (in order, $M = .2238, -.0061, \text{ and } -.2058$). Follow-up Tukey tests indicated that only the difference between the secure and anxious clusters was significant. Given the multiple between-group comparisons tested, this finding could have occurred by chance. However, it suggests, as would be expected, that securely attached individuals are more likely to report positive emotions.²⁶

Finally, highly significant differences in the likelihood of receiving a current or past mood disorder diagnosis emerged for attachment styles. Of the 191 participants who were interviewed with the mood disorder section of the SCID, 34 (17.8%) met diagnostic criteria for present or past mood disorder. Six males met criteria for a history of depression; 2 received diagnoses of dysthymia; and 2 received diagnoses of bipolar disorders. Thirteen females were diagnosed with current depression; 3 received diagnoses for a history of depression; 3 received diagnoses for dysthymia; 4 met criteria for hypomania; and 1 reported a history of anorexia but did not meet criteria for current mood disorders.²⁷ Due

²⁵ Similar findings emerged with MANOVAs for the first-order factors (for the self-classification groups, Wilks' Lambda exact $F(6, 366) = 1.88836, p < .08$; for the clusters, Wilks' Lambda exact $F(6, 366) = 2.1062, p < .052$).

²⁶ Among all these measures, sex effects emerged only for three of the Intrinsic Motivation scales: compared to males, females reported feeling less competence ($M = -.1884$ versus $.2125$; $F(1, 181) = 8.27, p < .0045, r^2 = .044$), feeling less enjoyment and interest ($M = -.1598$ versus $.1802$; $F(1, 181) = 5.90, p < .0161, r^2 = .032$), and exerting less effort ($M = -.1586$ versus $.1790$; $F(1, 181) = 7.21, p < .0079, r^2 = .038$) while completing the DS-CPT.

²⁷ Even with this final subject excluded, female participants' diagnosis rate was twice as great as that of males (22% versus 11%, chi square (1, $N = 191$) = 5.206, $p < .023$). The higher rate of mood disorder in DS-CPT participants compared to population norms is probably due to oversampling participants high in

to the small number of participants receiving positive diagnoses in a given diagnostic category, participants were combined into groups with or without any history of mood disorder.

Among the groups formed via the self-classification measure, the rate of mood disorder was 8.6% for the secure group, 26.7% for the avoidant group, and 61.5% for the anxious group (chi square (2, $N = 189$) = 26.675, $p < .001$, $\phi^2 = .141$). Among the clusters, the rate of mood disorder was 8.2% for the secure cluster (Cluster 1), 12.7% for the anxious cluster (Cluster 3), and 31.1% for the avoidant cluster (Cluster 2) (chi square (2, $N = 189$) = 12.132, $p < .002$, $\phi^2 = .064$). The association of mood disorder with impaired attachment is consistent with Bowlby's (1980) clinical observations and contemporary empirical work (for recent summaries see Diamond and Blatt [1994] and Adam [1994]).

Although attachment was significantly related to mood disorders in the expected directions, anhedonia was not. Participants who had a history of any mood disorder were no more likely to be anhedonic than were participants without a history of mood disorder ($F(1, 189) = .71$, ns). Similarly, participants who were diagnosed as currently depressed or dysthymic when they completed the DS-CPT also did not differ from DS-CPT participants who did not meet diagnostic criteria ($F(1, 189) = .00$, ns). However, participants with any history of mood disorder did have significantly higher levels of schizophrenism ($M = .8219$) than participants without this history ($M = .0199$, $F(1, 189) = 21.20$, $p < .0001$, $r^2 = .101$). This effect was diminished somewhat when participants were divided into groups with and without current depressive disorders, but depressed participants still reported significantly higher levels of schizophrenism ($M = .6962$) than non-depressed participants ($M = .1002$, $F(1, 189) = 6.99$, $p < .0089$, $r^2 = .035$).

schizophrenism. As reported below, a substantial relationship between schizophrenism and mood disorder emerged.

Summary of Attachment Style Differences. Participants classified themselves into secure, avoidant, and anxious attachment categories at rates consistent with prior research, and there were no sex differences in these categories. Cluster analysis yielded an ambiguous three-cluster solution that, while confirming the global distinction between insecure and secure attachment, did not provide decisive support for the classical attachment style triad; instead, the cluster solution appeared to divide participants into positive, average, and negative attachment groups. Nevertheless, the two methods of grouping participants yielded approximately the same between-group differences.

Compared to anxiously and avoidantly attached individuals, securely attached participants had greater ability to depend on others, greater ease with interpersonal closeness, and less concern about abandonment and reciprocity; they retrospectively reported more positive parenting and childhood peer relationships; they exhibited less tendency towards positive schizotypal disturbance, reported higher self-esteem, and were much less likely to receive current or past diagnoses of mood disorders. Secure participants also showed a marginal tendency to report less negative emotion when this was assessed with global factor scores and to have slightly higher social problem solving scores. Attachment style was unrelated to anhedonia, achievement orientation, attentional performance, effort exerted with the dynamometer, and any of the intrinsic motivation scales assessing subjective experience of the DS-CPT.

Anhedonia was associated with neither attachment style nor mood disorders, while schizophrenism was associated with both. The positive relationship between schizophrenism and impaired attachment replicates prior findings (Wilson and Costanzo 1995), and the significant relationship between mood disorders and schizophrenism is not surprising, given the frequency with which depression accompanies schizotypy and schizophrenia (Allen, Chapman, and Chapman 1987; Allen, Chapman, Chapman, Vachetich, and Frost 1987; American Psychiatric Association 1994). Although increases in

anhedonia might be expected with depression, the absence of such a relationship in the current sample is consistent with longitudinal findings reported by Chapman and Chapman (1987) and with reports that only a minority (12%) of depressed patients experience anhedonia (Clark and Fawcett 1987).

Step 3: Path Analysis Predicting Schizotypy

While the categorical analyses of attachment style reported above provide evidence for the continued importance of the classical attachment style triad in early adulthood, the following analyses examine the direct and indirect relationships between retrospectively reported parental and peer relations in childhood, current attachment, and schizotypal tendencies.²⁸ Path analysis is appropriate when there is a clear theoretical model of causality that can be tested; path analysis can confirm or disconfirm the causal links posited in the model to the extent that they are consistent with the data, but, like any other statistical technique, it cannot prove real-world causality. This is the case because there are generally alternative models that will fit the data equally well (Bollen 1989; MacCallum, Wegener, Uchino, and Fabrigar 1993). Thus, good model-to-data fit is a necessary but not sufficient condition to accept the model; the substantive meaning, parsimony, and interpretability of components (i.e., parameter estimates) must also be clear and reasonable.²⁹

In the present case two equally plausible models presented themselves for the prediction of schizophrenia and anhedonia. First, it was possible that global mothering,

²⁸ Originally, I intended to include participants' general orientations to causality in this path analysis. Individual differences in causality orientation appear readily predictable from attachment theory, and chronic disruptions in causality orientation (i.e., Deci and Ryan's (1985b) impersonal causality orientation) would be expected in the disordered interpersonal relations characteristic of schizotypy. However, the results of the confirmatory factor solutions for the causality scale items did not provide unambiguous evidence that the items were measuring causality orientation. Although potentially related to the issues I set out to investigate in this dissertation, social problem solving, low self-esteem, and achievement orientation were not part of any model I had hypothesized. Moreover, in the absence of a clear theoretical framework it was unclear where in the path such constructs should be positioned (e.g., does low self-esteem follow or precede schizotypy?). I therefore did not include them in this step of my analyses.

²⁹ The limits of path analysis are identical to those of confirmatory factor analysis; both are forms of structural equation modelling. See footnote 10.

global fathering, peer acceptance in childhood, and adult attachment were each directly predictive of schizophrenia and anhedonia. These path components are consistent with interpersonal models of schizophrenia, which formulate perceptual and cognitive distortions as arising from disturbances in important interpersonal relations, particularly early relations with parents. Alternatively, it was equally possible that the three retrospective measures of mothering, fathering, and peers acceptance only indirectly predicted schizophrenia and anhedonia through the mediating variable of adult attachment. Paths from global mothering, fathering, and peer acceptance to adult attachment are consistent with attachment theory, which posits a continuity of attachment across development that arises from early experiences with important others. In this mediation model, early relationships influence the quality of adult attachment, but it is the proximal variable, adult attachment, that is predictive of schizotypal tendencies.

Finally, in both the direct and mediational models, a bidirectional relationship between adult attachment and schizotypy was hypothesized. These components of the models represented the well-known observation that schizophrenic disturbances can profoundly disrupt interpersonal relationships (Gottesman 1991; Mishler and Waxler 1968; Nuechterlein et al. 1989; Wilson and Costanzo 1995), just as chronic disturbances in interpersonal relations appear to be associated with increased likelihood of schizophrenic distress, at least in those who are vulnerable (Goldstein, 1985, 1990; Leff and Vaughn, 1985). This feedback loop was modelled with the current data, using bidirectional path coefficients constrained to be of equal size.

Both the direct and mediational models were tested, with separate models predicting schizophrenia and anhedonia. In addition, given reports of gender differences regarding the onset and course of schizophrenic disorders (Andia and Zisook 1991; Castle, Abel, Takei, and Murray 1995; Goldstein and Kreisman 1988; Gottesman 1991; Gureje 1991), separate path models for each sex were tested. Results indicated that for both sexes, some

but not all paths from both the mediational and the direct models were significant. Therefore, for each sex, significant components from the direct and mediational models were combined to provide the most parsimonious representation of the relationships between adult attachment, childhood relations, and schizotypal tendencies. This resulted in four final models, one for each sex in the prediction of schizophrenia and anhedonia.

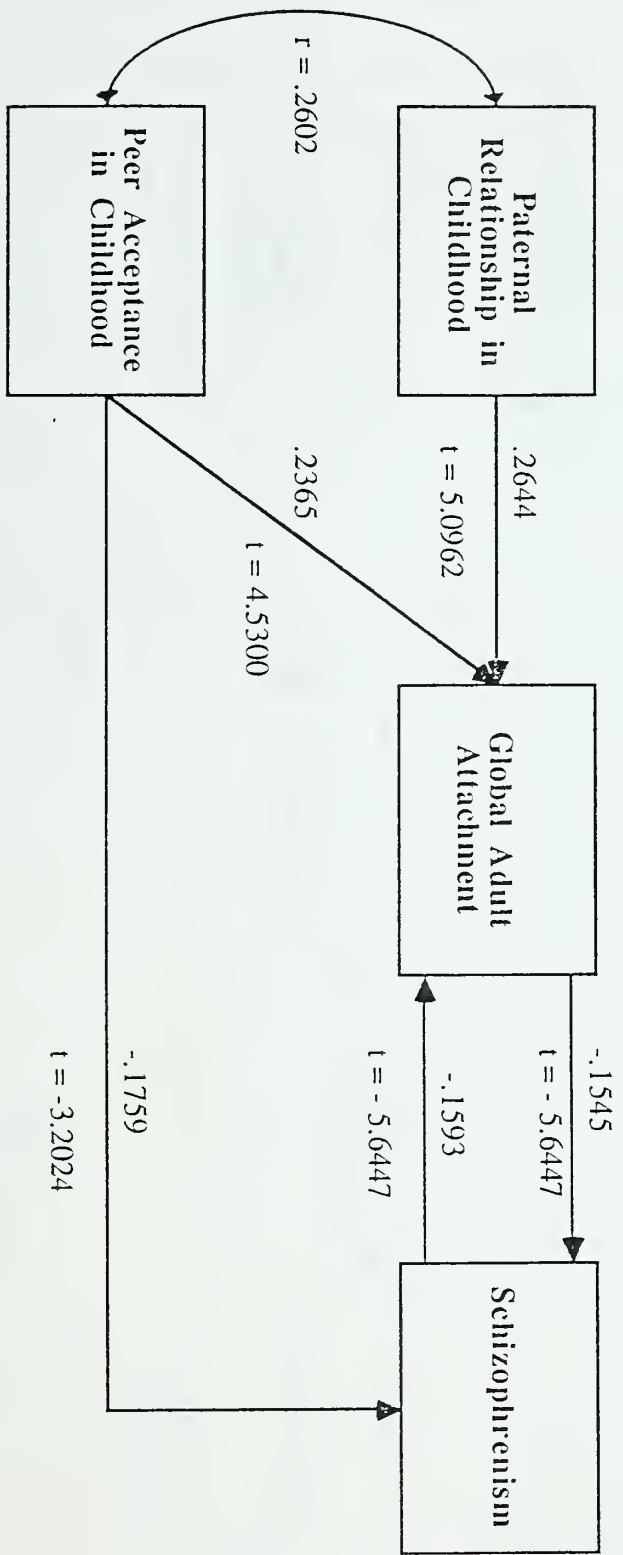
Prediction of schizophrenia. The optimal path models with standardized path coefficients³⁰ for the prediction of schizophrenia in females and males are shown in Figures 9 and 10, respectively. Surprisingly, for female participants, global mothering was *not* predictive of either adult attachment or schizophrenia. Global fathering scores significantly predicted adult attachment but had no direct influence on schizophrenia; peer acceptance scores predicted adult attachment and had both a direct and indirect (mediated) effect on schizophrenia; and, as the mediated effects imply, adult attachment significantly predicted schizophrenia.

Overall, the model fit extremely well: Goodness of Fit Index Adjusted for Degrees of Freedom, .9932; Bentler's Comparative Fit Index, 1.0000; Bentler and Bonett's Non-normed Index, 1.0285; Bentler and Bonett's Normed Index, .9969; Bollen's Normed Index Rho1, .99813; Bollen's Non-normed Index Delta2, 1.0046; root mean square residual, .0092. Total effects for each of the predictor variables on schizophrenia were as follows:³¹ global adult attachment, -.1545; global fathering, -.0408; and peer acceptance during childhood, -.2135. The final model accounted for 24.5% of the variance in adult attachment and 12.0% of the variance in schizophrenia.

³⁰ T-tests for the significance of path coefficients are also included in these figures; general practice is to retain path components with t values of 2.0 or greater.

³¹ Total effects are computed as the sum of the direct and indirect effects. Direct effects are given by the standardized beta coefficients, while indirect effects are given by the product of the beta coefficients for the paths linking the predictor to the mediator and the mediator to the outcome variable (Bollen 1989). Total effects for global fathering on schizophrenia are thus 0 (no direct effect) + (.2764 x -.3221) (the indirect effect) = -.0890. This value indicates that for a unit increase in the paternal relationship, there is a decrease of just less than a tenth of a unit in schizophrenia.

Figure 9. Path Diagram Predicting Schizophrenism for Female Participants (n=302)



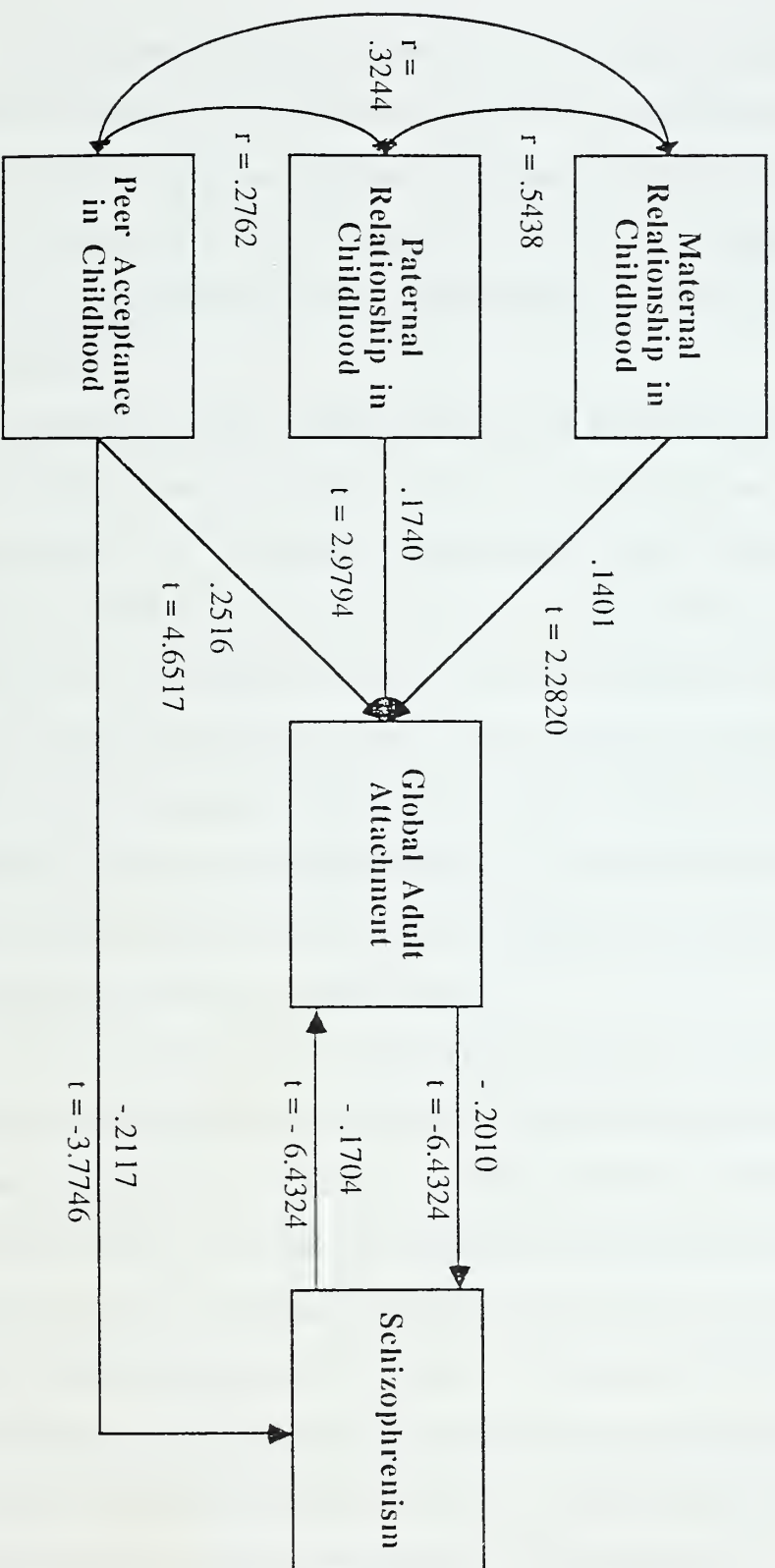


Figure 10. Path Diagram Predicting Schizophrenism for Male Participants (n=276)

The structure of the path diagram was similar for male participants, with the exception that global mothering, global fathering, and peer acceptance scores all predicted adult attachment. Again, adult attachment predicted schizophrenia, and peer acceptance had both an indirect and a direct influence on schizophrenia. Consistent with the model for female participants, neither of the global parenting variables had a direct effect on schizophrenia.

Overall fit was again excellent: Goodness of Fit Index Adjusted for Degrees of Freedom, .9865; Bentler's Comparative Fit Index, 1.0000; Bentler and Bonett's Non-normed Index, 1.0147; Bentler and Bonett's Normed Index, .9954; Bollen's Normed Index Rho1, .9769; Bollen's Non-normed Index Delta2, 1.0028; root mean square residual, .0131. Total effects for each of the predictor variables on schizophrenia are as follows: global adult attachment, -.2010; global mothering, -.0282; global fathering, -.0350; and peer acceptance during childhood, -.2623. The final model accounted for 30.4% of the variance in adult attachment and 17.7% of the variance in schizophrenia. Both total effects and the cumulative variance accounted for indicate that somewhat stronger effects were found for males than for females.

In summary, for females, recalled attachment to fathers and peers in childhood predicted adult attachment, and adult attachment and childhood peer attachment directly predicted schizophrenia. No path from recalled attachment to mothers was significant, and recalled attachment to fathers was significant in predicting schizophrenia only through the indirect path with adult attachment as the mediator. The reciprocal relationship between adult attachment and schizophrenia was supported. The model was the same for male participants, with the exception that recalled attachment to mothers predicted adult attachment. Although the models for both sexes fit well, the model for males predicted more of the variance in both adult attachment and schizophrenia.

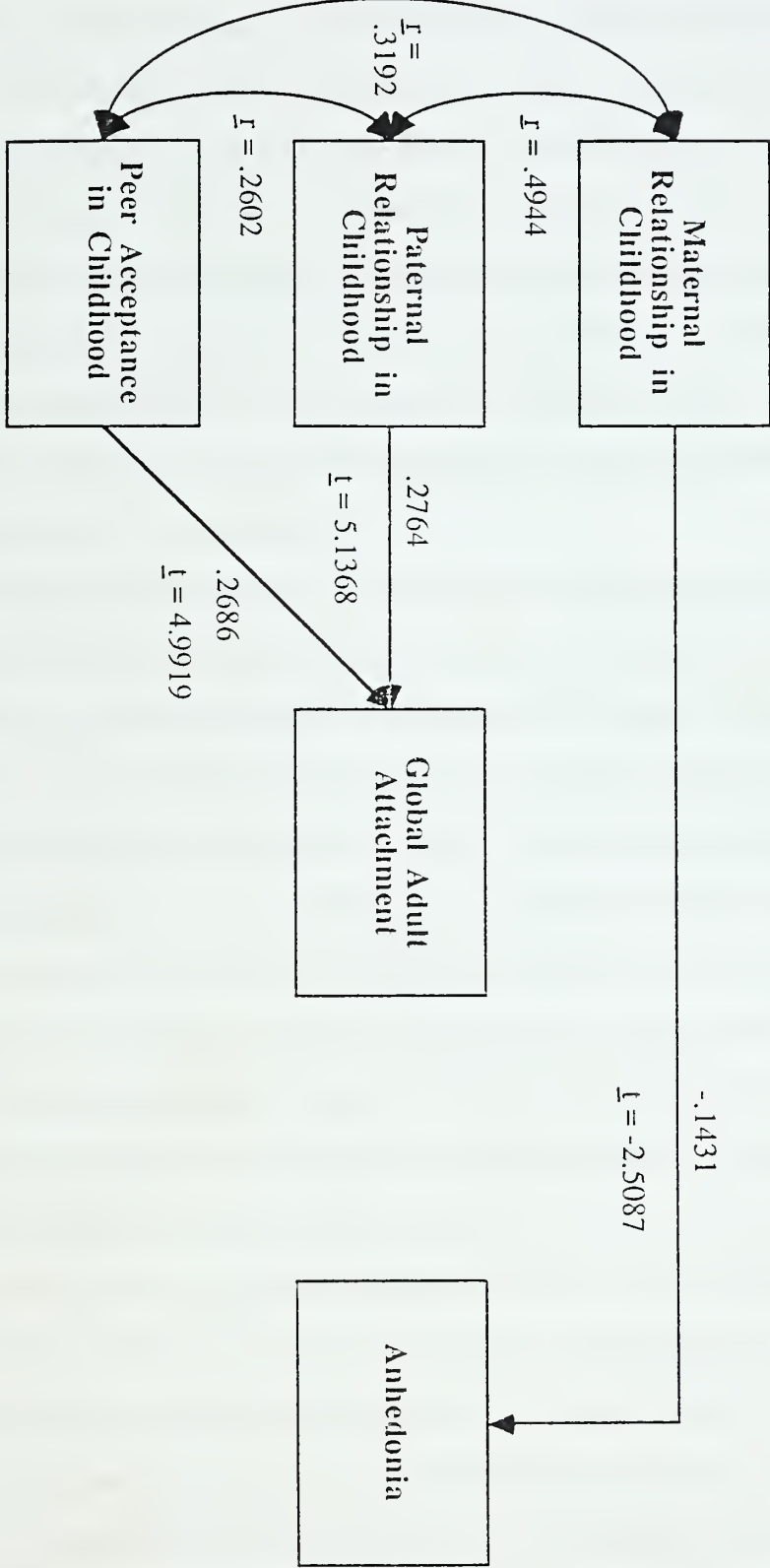
Prediction of anhedonia. As was the case for the models predicting schizophrenia, there were important sex differences in the prediction of anhedonia. For males, none of the attachment measures predicted anhedonia. For females, global mothering directly predicted anhedonia, but had no mediated effect, because it did not predict adult attachment. Both global fathering and peer acceptance in childhood directly predicted adult attachment but had no relation to anhedonia; and the reciprocal loop between adult attachment and anhedonia was not significant. The optimal path model for females is depicted in Figure 11.

The overall model fit well: Goodness of Fit Index Adjusted for Degrees of Freedom, .9818; Bentler's Comparative Fit Index, 1.0000; Bentler and Bonett's Non-normed Index, 1.0040; Bentler and Bonett's Normed Index, .9809; Bollen's Normed Index Rho1, .9522; Bollen's Non-normed Index Delta2, 1.0016; root mean square residual, .0226. The only significant effect in the prediction of anhedonia was that for global mothering, -.1431. Consistent with the lack of significant findings for anhedonia with categorical analyses of attachment and the nonsignificant path from adult attachment to anhedonia, the path model accounted for only 2.0% of the variance in anhedonia in females. Due to the absence of schizophrenia as a predictor of adult attachment, somewhat less of the variance in adult attachment was captured in the model shown in Figure 11 (18.7%) than in the earlier path model with schizophrenia included.

In summary, for females, recalled attachment with mothers in childhood predicted anhedonia, and paths leading to adult attachment were identical to those in the model predicting schizophrenia. For males, none of the attachment measures predicted anhedonia.

Summary of path models. The path models represented in Figures 9-11 indicate substantial relationships between schizophrenia and the interpersonal measures, but little to no relationship between anhedonia and the interpersonal measures. In addition, strong

Figure 11. Path Diagram Predicting Anhedonia for Female Participants (n=302)



relationships between adult attachment and childhood relations with parents and peers emerged. These findings are consistent with the categorical analyses presented earlier. The path models predicting schizophrenia provided additional information regarding the role of adult attachment in mediating the relationship between retrospectively reported childhood relationships and current schizotypal tendencies. The existence of both direct and indirect paths leading from childhood peer acceptance to schizophrenia is particularly noteworthy, as is the size of these effects, which are an order of magnitude larger than those for parental relationships in childhood. Fit indices supported the reciprocal loop modelled between schizophrenia and adult attachment.

The surprising finding that maternal relations in childhood did not predict adult attachment for female participants but did for males indicates that there may be important sex differences in the development of attachment for this sample. In addition, compared to the model for females, the model for males had slightly larger coefficients for the paths leading to schizophrenia and accounted for more of the variance in schizophrenia. This difference suggests that schizophrenia may be somewhat less related to the interpersonal measures for females than for males. With these exceptions, however, the models and path coefficients for both female and male participants appear basically similar.

In interpreting these path diagrams, it is important to keep in mind that any of the paths could be reversed with no change in overall goodness of fit or loss of parsimony. As noted earlier, there are generally multiple models that can explain the data equally well, and in the current case there are a number of equivalent models to consider (Bollen 1989; MacCallum et al. 1993). For instance, such reversals would mean that retrospective reports of childhood relationships are indicators, not causes, of adult attachment; that is, that adult attachment colors reports of childhood relationships. Thus, while it is particularly tempting to draw causal inferences from path diagrams, these data are unable to support or refute any claims regarding the direction of causality. The diagrams shown in

Figures 9-11 present one of many possible scenarios. However, they are consistent with developmental models that include psychosocial stressors among the etiological factors contributing to schizophrenic disorders.

Step 4: Prediction of DS-CPT Performance

Prediction of participants' DS-CPT performance was the central issue of this study. The primary predictor variables were motivational induction, schizotypy, and attachment, and the primary outcome variable was perceptual sensitivity. Participants' subjective experience while engaged in the DS-CPT, general emotional experience during the afternoon on which they completed the task, persistence with the hand-held dynamometer, and presence of mood disorder constituted important secondary predictor variables.³²

However, before these issues could be addressed, several factors had to be investigated. First, DS-CPT performance indices over the entire sample were examined, to confirm that (a) perceptual sensitivity declined over the course of the task, and (b) perceptual sensitivity was independent of response bias. These characteristics were required for the DS-CPT to qualify as a vigilance task and meet the assumptions of signal detection theory. Confirmation of these characteristics thus constituted an essential step in establishing the validity of the data. In this connection it was also necessary to confirm that these characteristics held in all three experimental conditions, to ensure that the insertion of motivational inductions into the protocol did not alter the nature of the vigilance task.

Second, it was necessary to confirm that the staggered random assignment of participants to motivational condition was successful at a statistical level in blocking on schizophrenism, anhedonia, and sex. Confirmation of successful blocking obviates the need to include these variables as covariates when testing the effect of motivational

³² It was also conceivable to predict attentional performance with the factors derived from Deci and Ryan's (1985b) General Causality Orientation Scale. However, given the increased likelihood of Type I errors generated by multiple tests, the unsatisfactory status of these factors, and the consequent difficulties in constructing hypotheses worth testing, I elected not to include these variables in analyses predicting DS-CPT performance.

induction. And third, it was important to test whether the motivational inductions influenced participants' subjective experience of the DS-CPT protocol. This was done by comparing participants' scores on the factors derived from Deci and Ryan's (unpublished) Intrinsic Motivation Inventory.

These preliminary analyses are reported below; with the exception of null findings for the effect of motivational induction on Intrinsic Motivation Inventory scores, all results were as predicted. After these results are described, the rationale for using growth curve modelling to predict DS-CPT performance is presented, followed by results of growth curve analyses.

DS-CPT characteristics. Both in terms of summary scores and within each of the six blocks, response bias B'' was unrelated to perceptual sensitivity A' ³³ (average $p > .30$). Similar results were found when correlations were computed within each motivational induction condition (for the standard condition, average $p > .53$; for the low autonomy condition, average $p > .45$; and for the intrinsic motivation condition, average $p > .28$). These findings confirmed that the perceptual sensitivity and response bias indices met the signal detection theory requirement of independence.

Over the entire sample, a significant drop in perceptual sensitivity emerged across the six experimental blocks ($F(1, 1144) = 98.62, p < .0001, r^2 = .079$). There was a smaller but still highly significant rise in response bias ($F(1, 1144) = 16.78, p < .0001, r^2 = .014$).³⁴ These effects are shown in Figures 12 and 13, respectively, and confirm that the DS-CPT operated as a true vigilance task, with participants becoming increasingly less

³³ Again, all computations were made with the transformed score using the formula recommended by Nuechterlein (1991; see footnote 24).

³⁴ When these tests were computed with growth curve modelling, using the six blocks as a simple fixed effect, slightly larger effects for block emerged: for perceptual sensitivity, $F(1, 1144) = 127.21, p < .0001$; for response bias, $F(1, 1144) = 27.16, p < .0001$. The larger effects are the result of controlling for individual deviations by modelling random effects, and demonstrate the enhanced sensitivity of growth curve modelling for these analyses.

discriminative and more conservative with time (Davies and Parasuraman 1982; Swets and Kristofferson 1970). With important variations, these patterns were recapitulated within each motivational induction conditions and are reported below. As may be seen in Figure 12, there was a curvilinear drop in perceptual sensitivity, with a slowing in the rate of decent apparent by the fifth and sixth blocks. This curvilinearity indicated that a logarithmic transformation would yield the more linear curve that is appropriate for growth curve modelling. Accordingly, all subsequent growth curve analyses used log-transformed values for perceptual sensitivity.

Assignment of participants to motivational condition. Staggered randomization of participants to the motivational induction conditions successfully divided participants into three groups that did not differ in levels of schizophrenia ($F(2, 188) = .20, p > .8$) or anhedonia ($F(2, 188) = .50, p > .6$). Because almost equal numbers of females and males participated in each condition, sex was also equally distributed among the three conditions. Finally, although no attempt was made to assign participants to the conditions based upon attachment, the three groups also showed no differences in the dimensional measures of Adult Attachment (exact Wilks' Lambda $F(6, 368) = .37, p > .89$). Thus, the effect of motivational induction on DS-CPT performance could be examined without including these variables as covariates.

Effect of motivational induction on participants' subjective experience of the DS-CPT. Contrary to expectation, no effect of the experimental manipulation was found on participants' reports of their subjective experience of the DS-CPT protocol as measured by first-order Intrinsic Motivation Inventory factors (exact Wilks' Lambda $F(10, 352) = .90, p > .5$). This indicated that participants across the three motivational conditions reported equal levels of perceived choice, competence, effort, pressure, and enjoyment and interest while engaged in the DS-CPT. However, using the second-order intrinsic motivation factor, a trend emerged ($F(1, 180) = 2.90, p < .0901$), indicating that participants in the

Figure 12. Decreasing Perceptual Sensitivity with Time on the DS-CPT

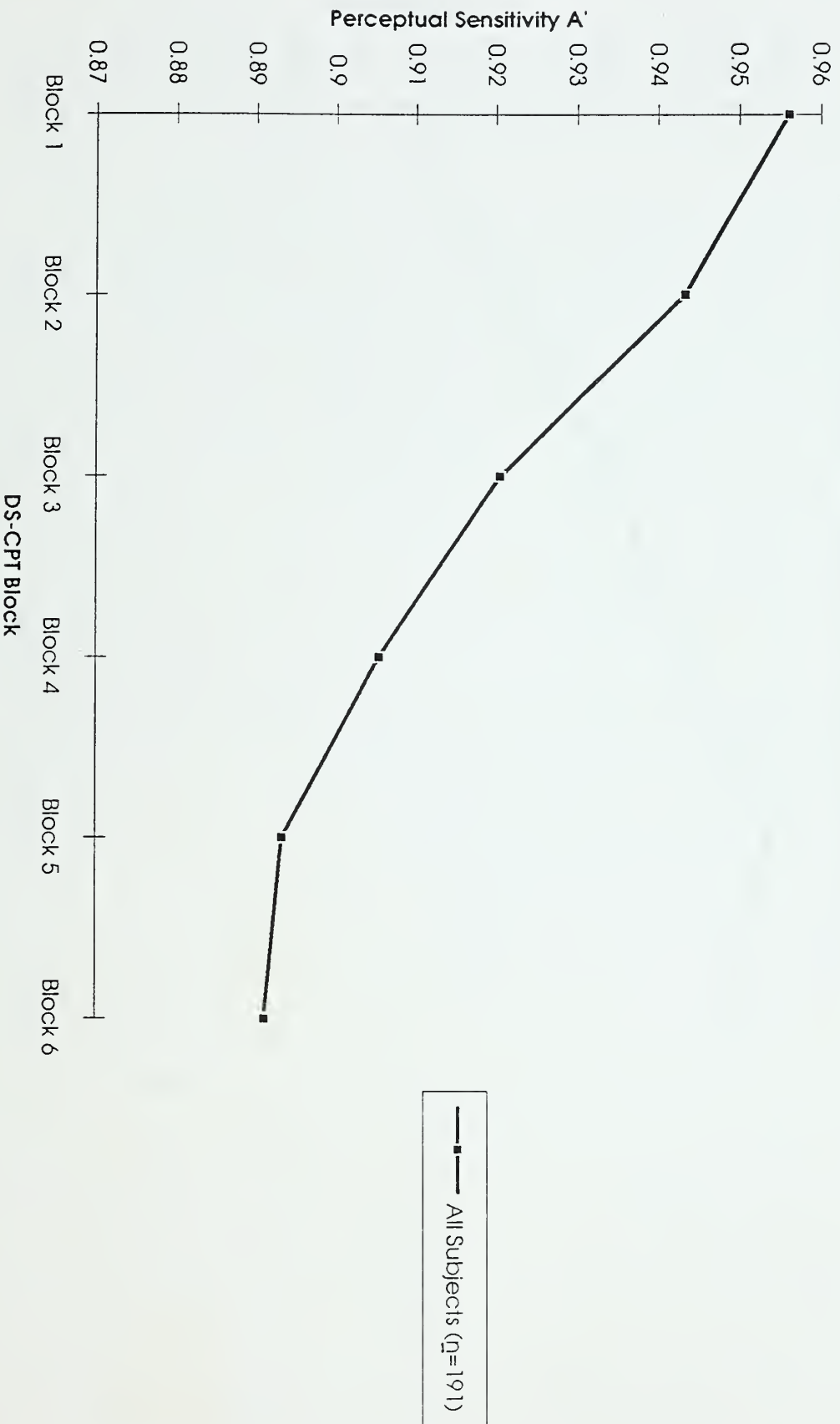
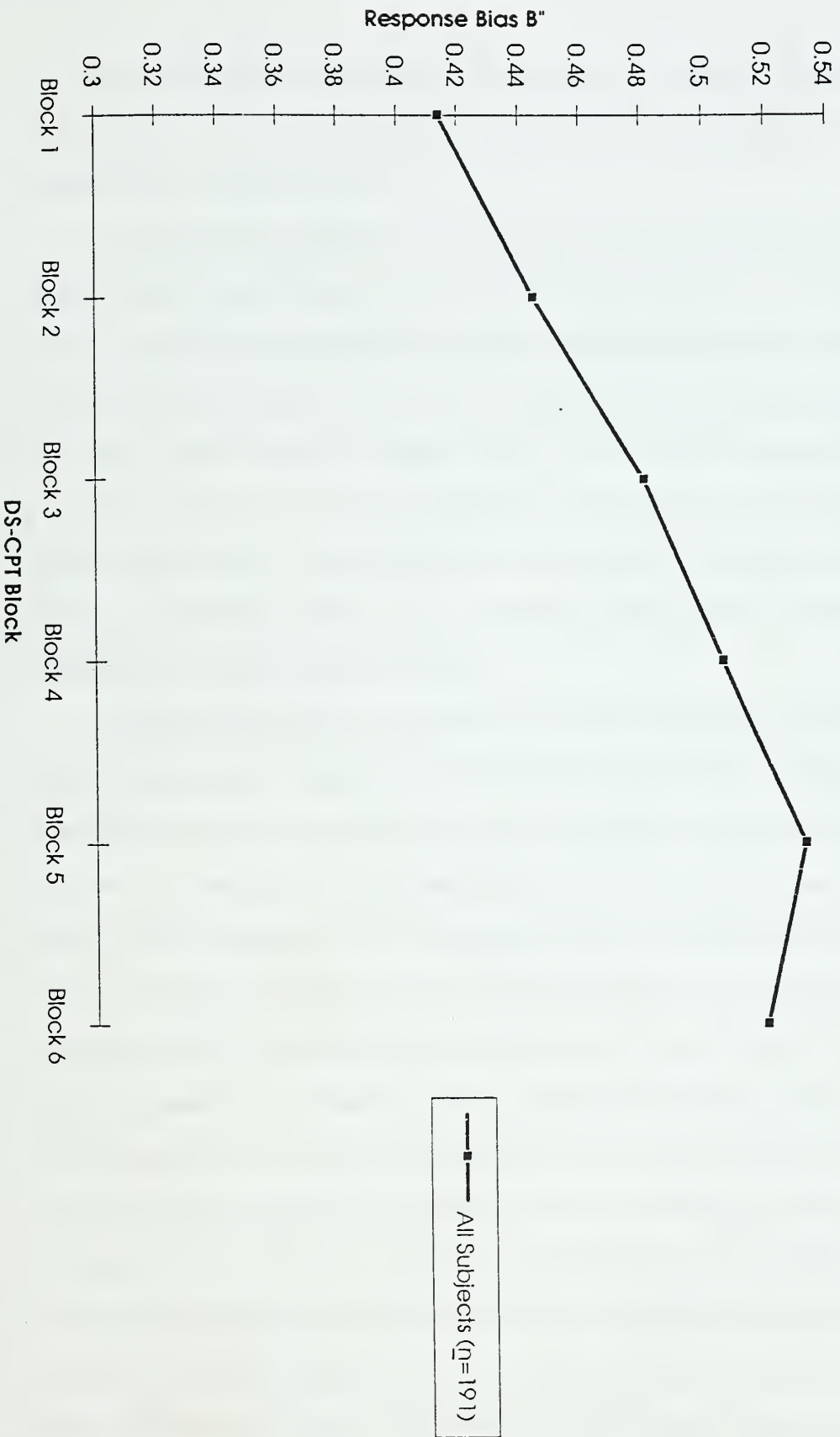


Figure 13. Increasing Response Bias with Time on the DS-CPT



high intrinsic motivation condition reported somewhat higher levels of global intrinsic motivation ($M = .1511$) than participants in either the low autonomy ($M = -.0443$) or standard ($M = -.0986$) conditions.

As measured by persistence in seconds on the hand held dynamometer task, the level of effort exerted by participants also did not differ by condition ($F(2, 188) = .48, p > .6$). Finally, the motivational inductions had no effect on the levels of positive, negative, and global emotions reported by participants for the afternoon in which they completed the DS-CPT (exact Wilks' Lambda $F(8, 368) = 1.00, p > .43$). Intrinsic motivation, effort, and global positive emotion also were not predicted by the interaction of attachment and motivational condition. These null findings would suggest that the three inductions were ineffective in producing different states of motivation and engagement. However, results of growth curve analyses indicate otherwise.

Growth curve analysis. In the past, schizophrenia researchers have generally sought to predict summary scores for the CPT. More rarely, they have analyzed the drop in perceptual sensitivity over the course of the CPT as either a simple difference of start and end scores or an interaction between performance and time. Although these techniques provide a global understanding of the association between attentional performance and variables of interest, they do not take advantage of the block-by-block performance scores typically available to researchers, and also do not permit precise inferences to be drawn about *how* predictors impact performance. Nuechterlein (1991) has pointed out that the field has generally ignored the question of whether schizophrenia spectrum disorders are associated with an average performance deficit across the entire course of the CPT, or with performance that may initially be identical to that of controls, but then declines more rapidly with time (but see Nestor et al. 1990). More careful consideration of how predictor variables influence CPT performance involves examination of both the starting level (or intercept) and the rate of change in performance (or slope) over the course of the task.

Although growth curve modelling has not previously been applied to CPT research, it is uniquely suited to the examination of these issues. Growth curve modelling is a well-established form of linear hierarchical modelling that simultaneously models (a) intraindividual change as a function of time and (b) interindividual change as a function of predictors. This mixed model analysis is appropriate when the data are in the form of repeated measures, the measurement is invariant over time, there is a reasonably large ratio of sample size to number of occasions of measurement, and the central questions have to do with change (see Burchinal and Appelbaum [1991] and Willett and Sayer [1994] for pertinent discussions). Mixed model analysis is appropriate here because the same measurements were taken over the six blocks of the DS-CPT, 191 participants were measured on six separate blocks, and the key questions have to do with participants' changing attentional performance over the course of task.

Both levels of the growth curve model are given by straightforward linear equations.³⁵ In the present case, the intraindividual growth trajectory, or Level 1 model, is given by:

$$\text{DS-CPT Performance}_{it} = \pi_{0i} + \pi_{1i} T_{it} + e_{it},$$

where DS-CPT Performance_{it} represents the observed level of either perceptual sensitivity or response bias for individual *i* at time *t*, π_{0i} is the estimated intercept, or starting level, for individual *i* at time 0, π_{1i} is the estimated linear rate of change in performance (or slope) for individual *i*, T_{it} represents the time of assessment for individual *i* (e.g., one of the six blocks measured), and e_{it} is the *i*th individual's deviation from an error-free linear model. For ease of interpretation, *T* was coded 0 for block 1, 1 for block 2, and so on through 5 for block 6. Thus, all individuals at this level of the model are considered to have the same basic growth trajectory as a function of starting level of DS-CPT performance and time.

³⁵ My presentation of these equations closely follows very clear expositions provided by Coie, Terry, Lenox, Lochman, and Hyman (in press) and Willett and Sayer (1994).

The second level of analysis, or Level 2 models, tests the existence of fixed group effects that could influence individual growth curve trajectories by producing variation in either of the two individual growth curve parameters (π_{0i} and π_{1i}). For the two primary fixed effects hypothesized to affect attentional performance, motivational induction condition and schizotypy, the Level 2 models for intercept and slope are given in order by:

$$\pi_{0i} = \beta_{00} + \beta_{01} \text{schizophrenism} + \beta_{02} \text{anhedonia} + \beta_{03} \text{condition} + \\ \beta_{04} \text{schizophrenism*anhedonia} + \beta_{05} \text{schizophrenism*condition} + \\ \beta_{06} \text{anhedonia*condition} + \beta_{07} \text{schizophrenism*anhedonia*condition} + \partial_{0i},$$

and

$$\pi_{1i} = \beta_{10} + \beta_{11} \text{schizophrenism} + \beta_{12} \text{anhedonia} + \beta_{13} \text{condition} + \\ \beta_{14} \text{schizophrenism*anhedonia} + \beta_{15} \text{schizophrenism*condition} + \\ \beta_{16} \text{anhedonia*condition} + \beta_{17} \text{schizophrenism*anhedonia*condition} + \partial_{1i}.$$

Here, schizophrenia and anhedonia represent factor scores on the dimension identified through confirmatory factor analysis, condition represents the motivation induction that participants received, the β 's represent standard regression coefficients, and ∂_{0i} and ∂_{1i} represent the i th individual's deviations from the estimated group intercept and slope, respectively. Interactions between schizotypy and motivational induction are included in these models because it is possible that individuals might be differentially influenced by the motivational induction depending upon their level of schizotypy.

In the full hierarchical model, both levels are combined and tested simultaneously:

DS-CPT Performance =

$$\beta_{00} + \beta_{01} \text{schizophrenism} + \beta_{02} \text{anhedonia} + \beta_{03} \text{condition} + \\ \beta_{04} \text{schizophrenism*anhedonia} + \beta_{05} \text{schizophrenism*condition} + \\ \beta_{06} \text{anhedonia*condition} + \beta_{07} \text{schizophrenism*anhedonia*condition} + \partial_{0i} + \\ \beta_{10}*T_{it} + \beta_{11} \text{schizophrenism}*T_{it} + \beta_{12} \text{anhedonia}*T_{it} + \beta_{13} \text{condition}*T_{it} + \\ \beta_{14} \text{schizophrenism*anhedonia}*T_{it} + \beta_{15} \text{schizophrenism*condition}*T_{it} +$$

$$\beta_{16} \text{ anhedonia} * \text{condition} * T_{it} + \beta_{17} \text{ schizophrenia} * \text{anhedonia} * \text{condition} * T_{it} + \delta_{1i} + e_{it}.$$

Thus, performance on the DS-CPT is modelled as (a) estimated group differences in intercept, or starting level of performance, (b) estimated group differences in slope, or change in performance over the six DS-CPT blocks, (c) error terms representing individuals' deviations from the estimated group-specific parameters for intercept and slope, and (d) a final error term representing participants' deviations from the simple model of change as a linear function of time. At the intraindividual level, this model represents change in perceptual sensitivity (or response bias) as a simple linear function of time. At the between-individual level, this model represents both the starting level and the decline in perceptual discriminability over time (or rise in response bias over time) as functions of schizotypy, motivational induction condition, and their interaction.

In the following analyses, this full mixed model was evaluated; fixed effects that were significant were retained for reduced models, until a parsimonious growth curve model containing only significant terms was obtained. Additional models for the other fixed effects of interest (attachment, intrinsic motivation, effort, emotion, and presence of mood disorder) were tested in the same manner. In all models, the Level 1 or intraindividual effects models were significant for the intercept and slope, with both p values $< .0001$. I used an unstructured covariance matrix in the analyses in order to permit the intercept and slope to be correlated; this correlation appeared to be a reasonable assumption and was usually significant in the Level 1 models.³⁶ Significance at the

³⁶ Whether this correlation was significant depended on the Level 2 models included in the full growth curve model. The alternative to permitting the intercept and slope to be correlated is, of course, to force them to be orthogonal. Such independence requires a stronger set of assumptions than appear warranted for the DS-CPT.

intraindividual level, together with the significant interindividual results reported below, confirm the appropriateness of using a mixed model to predict DS-CPT data.³⁷

Effect of schizotypy and motivational induction on DS-CPT performance. For perceptual sensitivity, the interaction between schizophrenia and anhedonia was significant in predicting the intercept ($F(1, 1139) = 4.69, p < .0305$), as was the main effect for schizophrenia ($F(1, 1139) = 11.41, p < .0008$); the main effect for anhedonia approached significance in predicting the intercept ($F(1, 1139) = 3.16, p < .0757$). The main effect for motivational condition on the slope was also highly significant ($F(3, 1139) = 44.00, p < .0001$, respectively). The interaction between schizophrenia and anhedonia indicated that when both were elevated, perceptual sensitivity was lowered across the six blocks; the schizotypy scales had no effect on the rate of drop off in perceptual sensitivity over the course of time. This effect is illustrated in Figure 14, with participants above the mean in both schizophrenia and anhedonia ($n = 38$) contrasted with all other DS-CPT participants ($n = 153$); for these arbitrarily divided groups, a post hoc contrast indicated lower intercepts for the high schizotypy group compared to other participants ($F(1, 1139) = 6.40, p < .0115$). The interaction between schizophrenia and anhedonia was not quite significant in predicting summary perceptual sensitivity scores ($F(1, 187) = 2.87, p < .0918$). However, by themselves, main effects for schizophrenia and anhedonia were predictive of summary perceptual sensitivity scores ($F(1, 188) = 9.87, p < .0020$, and $F(1, 188) = 4.81, p < .0295$, respectively; cumulative $r^2 = .053$). Using the formula provided by Hunter and Schmidt (1990, p. 273), this produced an effect size of $d = .4730$.

Motivational induction differentially influenced the slope of perceptual sensitivity across the six blocks, and this effect is illustrated in Figure 15. As this figure shows,

³⁷ Growth curve modelling was conducted to predict both perceptual sensitivity and response bias. Analyses for perceptual sensitivity are reported in the text. Analyses for response bias, which were conducted in part to explore relationships between the predictor variables and participants' response strategies, are reported in Appendix D when significant.

Figure 14. High and Low Schizotypy Participants' Perceptual Sensitivity Scores on the DS-CPT

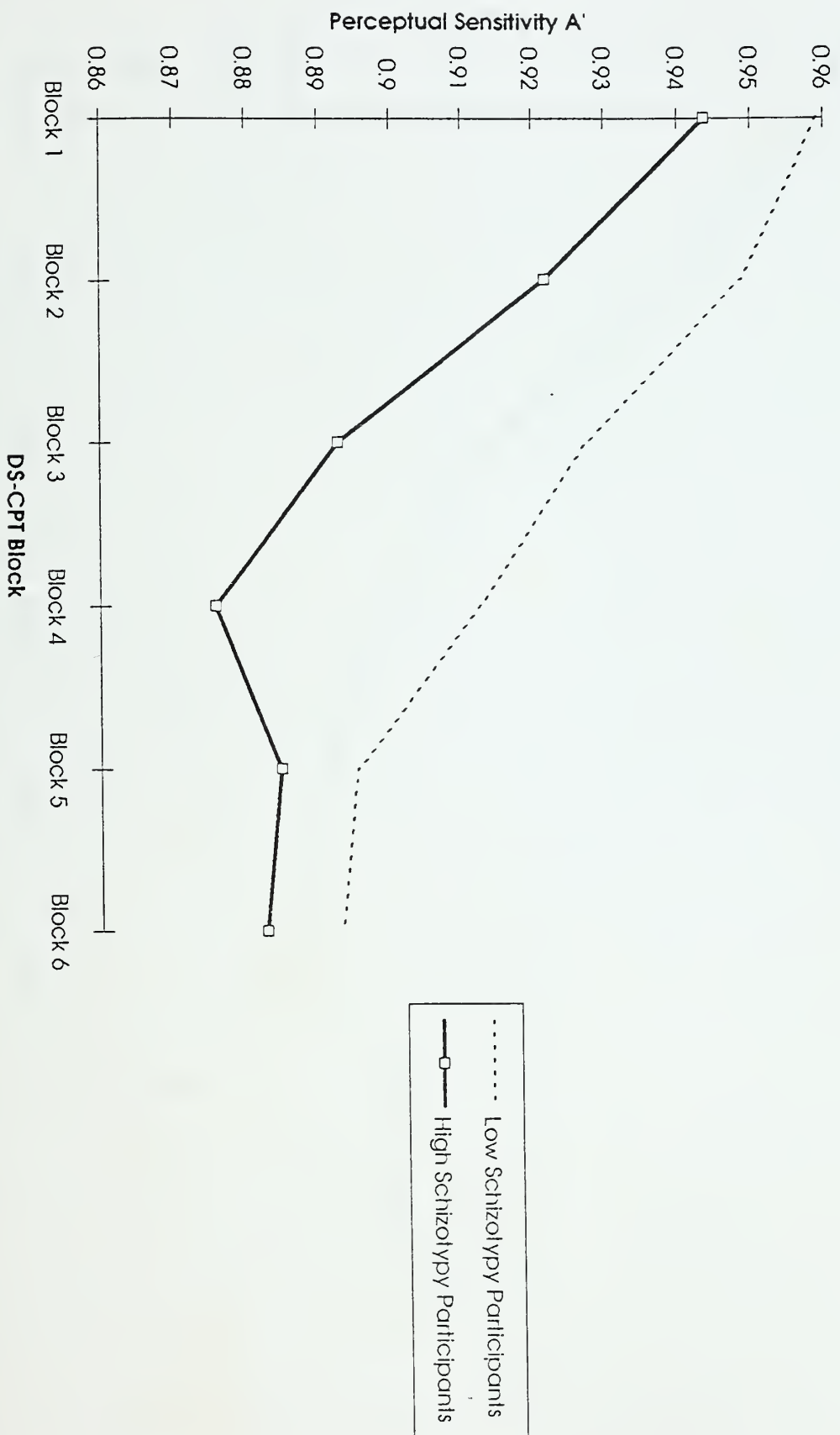
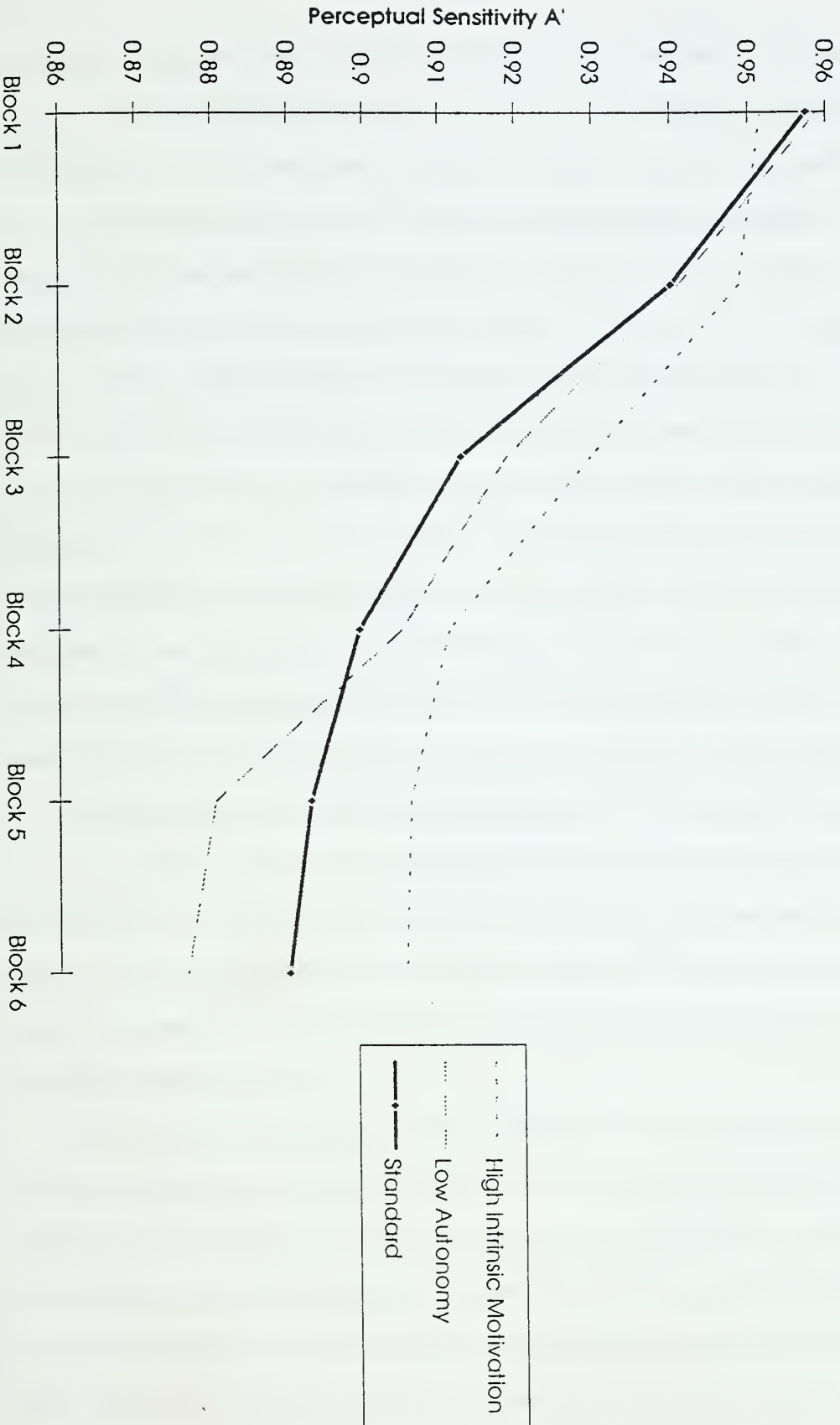


Figure 15. The Effect of Motivational Inductions on Perceptual Sensitivity



relative to participants in the standard DS-CPT induction, participants in the intrinsic motivation condition had decreased, and those in the the low autonomy condition had increased, rates at which perceptual sensitivity diminished over time. Parameter estimates for the slopes under the three conditions are consistent with such a conclusion: the slope was greatest for the low autonomy condition ($\beta = -.0240$, $t(1141) = -7.84$, $p < .0001$), least for the high intrinsic motivation condition ($\beta = -.0159$, $t(1141) = -5.22$, $p < .0001$), and intermediate for the standard induction condition ($\beta = -.0203$, $t(1141) = -6.73$, $p < .0001$). However, follow-up pairwise contrasts indicated that only the difference between slopes in the high intrinsic motivation and low autonomy conditions approached significance ($F(1, 1141) = 3.45$, $p < .0637$). As indicated in Figure 15 and by a post hoc contrast, this difference in slopes resulted in a marginal group separation in perceptual sensitivity by the sixth block of the DS-CPT ($F(2, 188) = 2.41$, $p < .1226$). Finally, despite their highly significant effect on the slope, motivational inductions did not affect overall perceptual sensitivity averaged across the six blocks ($F(2, 188) = .49$, ns).

Effect of attachment on DS-CPT performance. As expected, global attachment had no effect on either the intercept or slope for perceptual sensitivity; it also did not interact with motivational induction or schizotypy to predict either growth curve parameter (all p values $> .47$). Similarly, global attachment had no effect on either the intercept or slope for response bias, and again did not interact with motivational induction to predict either of these parameters (all p values $> .31$).

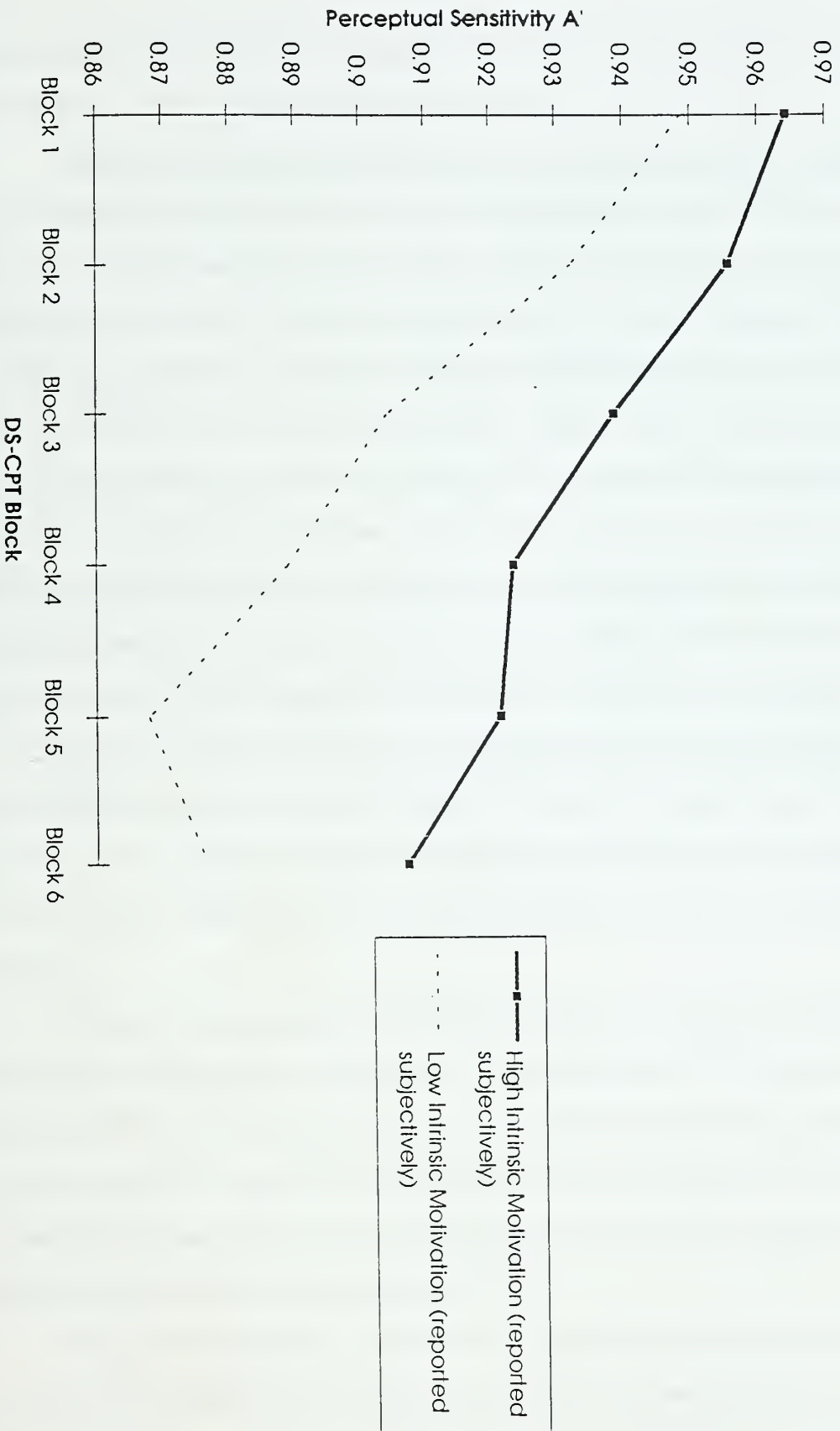
Post-experimental measures. While the effects of motivational induction on DS-CPT performance appeared to indicate differential engagement in the protocol, by themselves these findings do not clarify how the motivational inductions operated on attentional processes to produce variations in performance. Because the set of factors derived from Deci and Ryan's Intrinsic Motivation Inventory, the measure of effort derived from the hand-held dynamometer task, and subjective reports of emotional experience were all

unrelated to the motivational inductions, these variables could not be considered as candidates for mediating the effect of the experimental manipulations on attentional performance.

However, a separate question was whether these variables could independently predict DS-CPT performance. Indeed, increased levels of intrinsic motivation, persistence, and positive emotion should each signal the presence of greater engagement in the DS-CPT protocol. The three potential predictors were first investigated independently, because their individual contribution to attentional performance constitute distinct components of participants' engagement in the protocol. They were then jointly entered into a full model with schizophrenia in order to assess the relative contribution of each factor to perceptual sensitivity. While intrinsic motivation and positive emotion were moderately positively correlated with each other ($r = .2230$, $p < .0025$), neither were correlated with the measure of effort ($p > .98$ and $p > .83$, respectively). These measures are thus largely non-redundant. Findings for the global intrinsic motivation factor are reported first, followed by those for the persistence measure of effort and the global emotionality factor.

Effect of intrinsic motivation on DS-CPT performance. For perceptual sensitivity, global intrinsic motivation was significantly predictive of the intercept ($F(1, 1093) = 15.30$, $p < .0001$) but not the slope. Intrinsic motivation also did not interact with motivational condition, schizophrenia, or anhedonia to predict either of the two growth curve parameters. The main effect for intrinsic motivation on initial levels of perceptual sensitivity is illustrated in Figure 16, using a split along the mean to divide participants into groups of high and low intrinsic motivation. As can be seen there, individuals reporting higher levels of intrinsic motivation (i.e., greater enjoyment, interest, sense of choice, effort, and competence, and less pressure/tension) consistently had higher perceptual sensitivity scores than individuals reporting low levels of intrinsic motivation. This positive influence of increased intrinsic motivation on attentional performance was also

Figure 16. The Effect of High and Low Intrinsic Motivation on Perceptual Sensitivity



highly significant for the global measure of perceptual sensitivity averaged across the six blocks ($F(1, 181) = 23.27, p < .0001, \eta^2 = .114$).

Relationship of effort as assessed by the dynamometer task to DS-CPT performance.

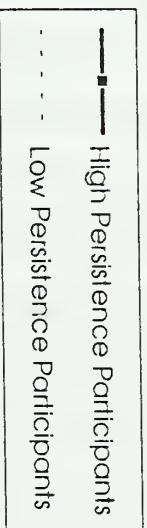
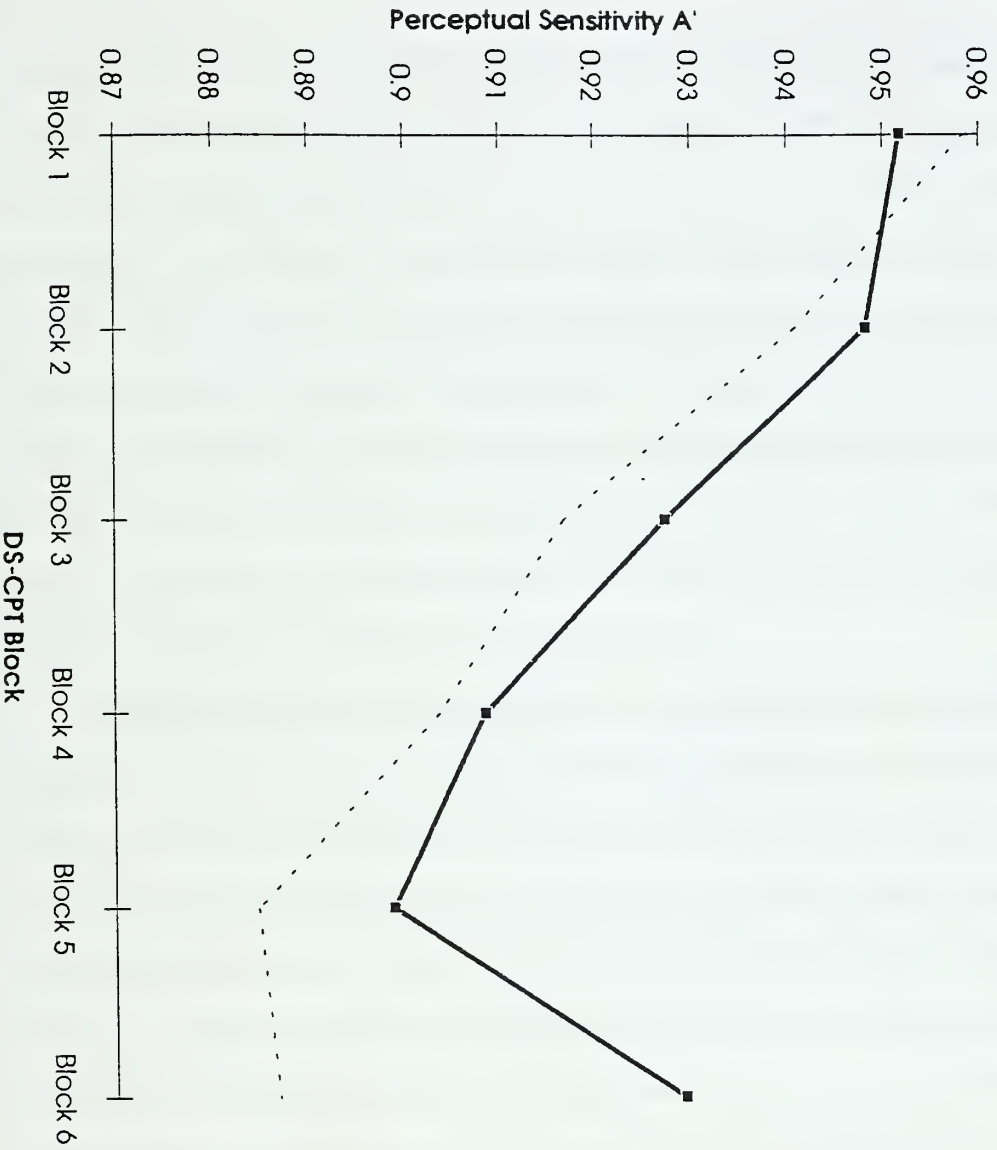
The second participant variable that could bear a relationship to attentional performance was the degree of effort participants were willing to produce in the laboratory setting following completion of the DS-CPT, as indexed by persistence at the hand-held dynamometer task.

For perceptual sensitivity, there was a main effect of effort on the slope after controlling for the effect of motivational induction, $F(1, 1141) = 4.30, p < .0384$. Effort did not predict initial levels of perceptual sensitivity and also did not interact with either schizophrenia, anhedonia, or motivational condition to predict the two growth curve parameters. The association between persistence as assessed by the hand-held dynamometer and persistence at perceptual sensitivity is illustrated in Figure 17, using a split at the mean to divide participants into groups of high and low persistence. As can be seen in this figure, participants who persisted longer with the hand-held dynamometer showed a smaller decrement in perceptual sensitivity over time, and in fact "recovered" perceptual sensitivity in the final block, while participants who persisted for shorter periods with the dynamometer showed a steady, larger decrement in perceptual sensitivity over time, with no period of recovery.

Effect of positive emotion on DS-CPT performance. Emotional experience was a third participant variable that could influence engagement in the DS-CPT protocol. Participants' global emotionality scores, derived from their reports of their general mood during the afternoon on which they participated in the DS-CPT protocol, were used as the independent variable for these analyses; higher global emotion scores corresponded to increased positive and decreased negative emotion.

For perceptual sensitivity, global positive emotion did not affect the slope and did not interact with schizophrenia or motivational induction to predict either the intercept or

Figure 17. The Relationship between Persistence and Perceptual Sensitivity

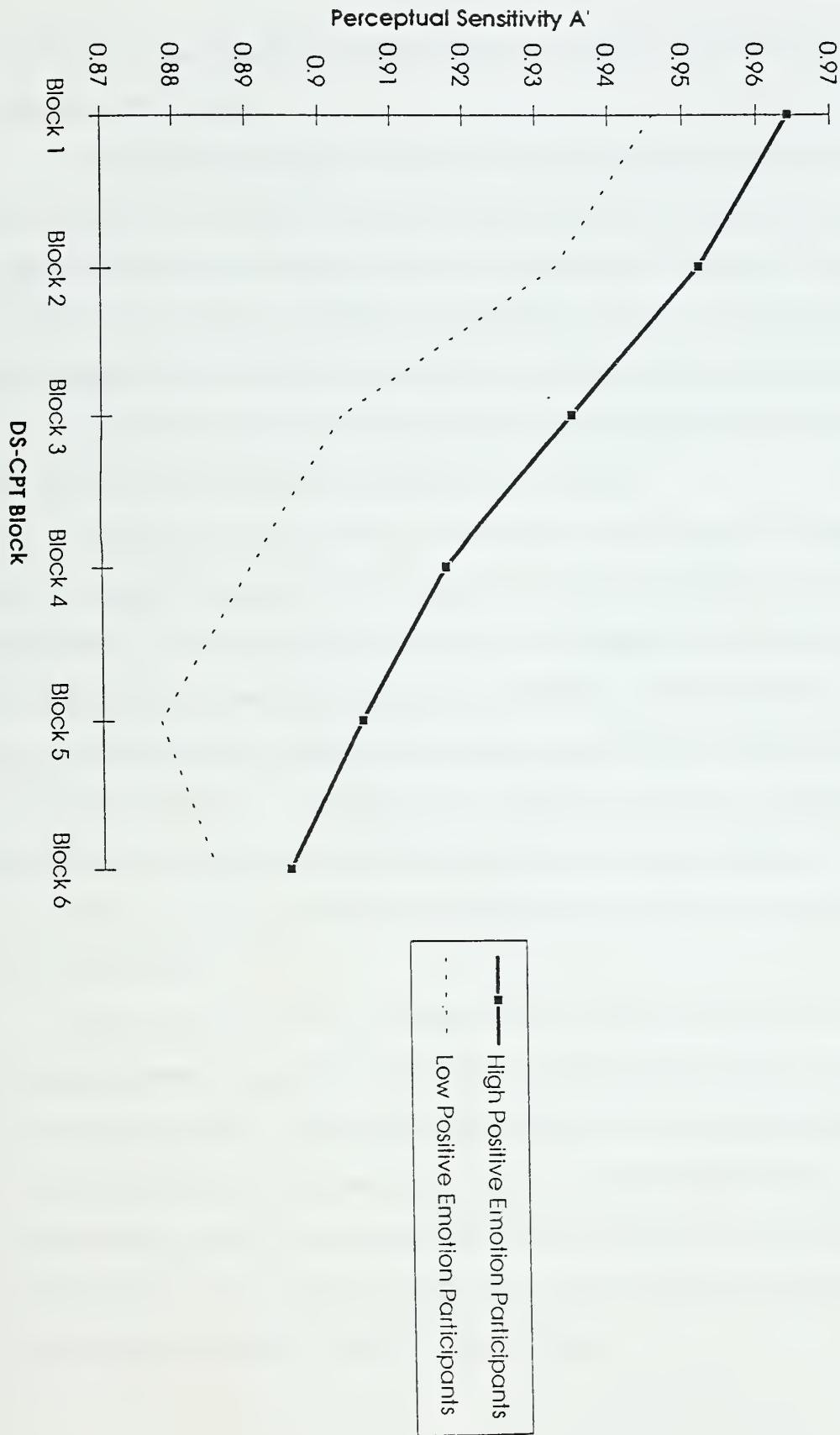


the slope. However, the main effect of global emotionality significantly predicted the intercept for perceptual sensitivity ($F(1, 1135) = 4.15, p < .0419$). Figure 18 illustrates this effect using groups that are split at the mean into high and low positive emotion participants. As can be seen, participants who reported higher global levels of positive emotion for the afternoon on which they completed the DS-CPT had consistently higher perceptual sensitivity scores than did participants who reported lower levels of positive emotion. This effect was also significant when assessed using the summary scores for perceptual sensitivity averaged over the six blocks ($F(1, 188) = 5.45, p < .0206, \eta^2 = .028$). Thus, the effect of global emotionality on perceptual sensitivity is similar to but somewhat smaller than the effect of intrinsic motivation.

Synthesis of findings with post-experimental measures and schizophrenia.

Participants' intrinsic motivation, positive emotion, and persistence all significantly predicted perceptual sensitivity levels. Increases in any of these three factors resulted in improved attentional performance. Greater intrinsic motivation and positive emotion were associated with increases in initial levels of perceptual sensitivity but had no effect on the subsequent duration-related decline in perceptual sensitivity; as a result, participants reporting higher levels of either factor performed better across all six blocks of the DS-CPT than participants reporting lower levels (Figures 16 and 18). Greater persistence resulted in a smaller decline in perceptual sensitivity, that is, in greater persistence in perceptual sensitivity (Figure 17). Although the emotion measure was moderately negatively correlated with schizophrenia ($r = -.2523, p < .0019$), it was not correlated with anhedonia ($p > .47$). Intrinsic motivation and persistence were correlated with neither schizophrenia ($p > .13$ and $p > .62$, respectively) nor anhedonia ($p > .73$ and $p > .23$, respectively). Intrinsic motivation and persistence therefore represent effects that were independent of both negative and positive schizotypy; all three factors provide an

Figure 18. The Effect of High and Low Positive Emotion on Perceptual Sensitivity



accumulation of evidence that perceptual sensitivity is related to motivational state and participant engagement.

Thus, attentional impairments detected through application of signal detection indices to the DS-CPT cannot be ascribed solely to a schizotypy-related deficit: individual differences in intrinsic motivation, emotional experience, and willingness to expend effort in the laboratory situation also influence performance. Because none of these factors or the motivational inductions interacted with schizotypy to predict attentional performance, there was no differential increase in performance for high and low schizotypal participants, depending on level of engagement or motivational induction.

However, the analyses thus far do not address the simultaneous but independent contributions that schizotypy and task engagement make to the prediction of attentional performance. To investigate this issue, a full model predicting perceptual sensitivity was tested, using schizophrenia, anhedonia, their interaction, intrinsic motivation, and positive emotion as main effects for the intercept, and motivational induction and effort as main effects for the slope. I tested this model to detect the schizotypy-related deficit in perceptual sensitivity that remained after controlling for motivational factors. As usual, nonsignificant terms were eliminated until a parsimonious model containing only significant effects was obtained.

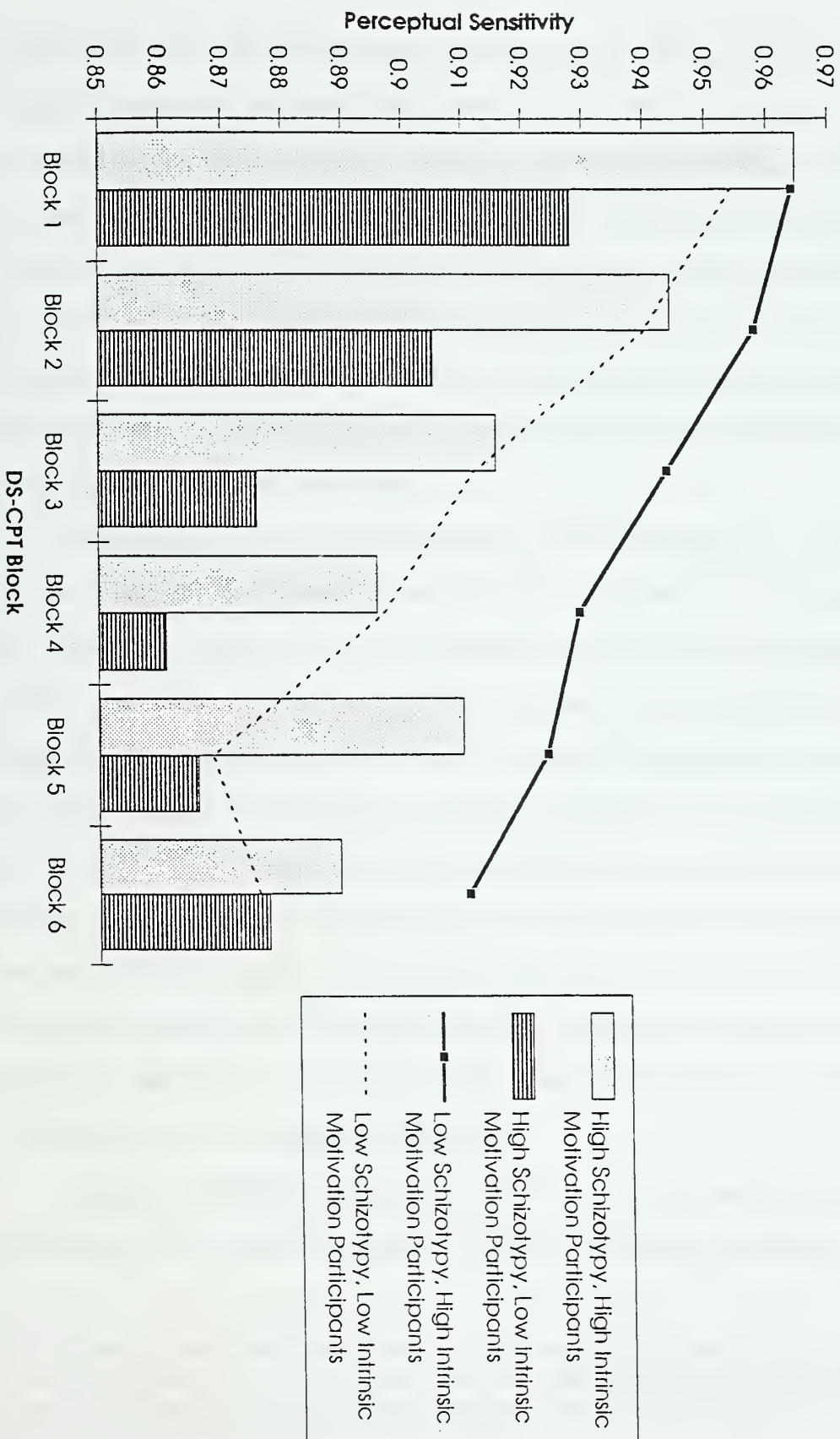
In the final reduced model, the main effects for intrinsic motivation and schizophrenia were significant in predicting the intercept ($F(1, 1090) = 11.75, p < .0006$, and $F(1, 1090) = 5.97, p < .0147$, respectively). The interaction between schizophrenia and anhedonia was close to significant in predicting the intercept ($F(1, 1090) = 3.66, p < .0560$), and again the main effect for anhedonia was not significant ($F(1, 1090) = 2.51, p > .11$). The main effect for motivational induction remained significant in predicting the slope ($F(3, 1092) = 42.17, p < .0001$).

As expected from the lack of significant correlations and interactions between intrinsic motivation and schizotypy, controlling for motivation did not reduce the effect for schizophrenia. Adjusting for motivation thus did not influence the effect for schizophrenia: adjusted and unadjusted means did not differ. The same findings emerged for models predicting summary perceptual sensitivity scores averaged over the six blocks: schizophrenia remained significant after controlling for motivation, and adjusting for motivation did not reduce the gap in perceptual sensitivity between high and low schizophrenia participants. Thus, to the limits of the measures employed in this study, the attentional impairment associated with schizophrenia does not appear to be accounted for by motivational variables.

Simply put, these analyses point to two completely independent effects for perceptual sensitivity: one for schizotypy (the schizophrenia x anhedonia interaction) and one for intrinsic motivation. While controlling for one of these effects does not change the influence of the other effect, their additive influence on perceptual sensitivity must be considered. Additive effects are illustrated in Figure 19, with participants grouped by schizotypy and motivation. High schizophrenia, high anhedonia participants [$n = 38$] constituted the high schizotypy group, while all other DS-CPT participants constituted the low schizotypy group; these two groups were divided into participants above and below the mean in intrinsic motivation.

Figure 19 shows how the additive effects of intrinsic motivation and schizotypy can produce different levels of perceptual sensitivity. High levels of intrinsic motivation appear to compensate partially for schizotypy-related impairment: the high schizotypy, high intrinsic motivation group did about as well as the low schizotypy, low intrinsic motivation group, although not as well as the low schizotypy, high intrinsic motivation group. The high schizotypy, low intrinsic motivation group exhibited the lowest levels of perceptual

Figure 19. Additive Effects of Schizotypy and Motivation on Perceptual Sensitivity



sensitivity.³⁸ Thus, being highly motivated during the DS-CPT protocol raises perceptual sensitivity regardless of schizotypy level, while having schizotypal tendencies depresses perceptual sensitivity regardless of motivation level. From the standpoint of CPT research, the crucial effect may be the increase in perceptual sensitivity accompanying higher levels of intrinsic motivation. This effect appears to lift schizotypal participants out of the extremely impaired range and back into normal ranges of perceptual sensitivity.

Differences in motivation therefore may account for the finding that only subgroups of schizophrenics and those at risk for schizophrenia-spectrum disorders display lowered perceptual sensitivity relative to controls.

Relationship between mood disorder and DS-CPT performance. Finally, I examined whether mood disorder influenced attentional performance. Participants were first divided into groups based upon the presence or absence of any mood disorder, either past or current. A second, more stringent division was based solely upon the presence or absence of *current* depression or dysthymia. Using either classification, no main effect or first-order interaction with motivational condition was significant in predicting both perceptual sensitivity (average *p* value for tests of significance = .49) or response bias (average *p* value for tests of significance = .65). Confirmation that attentional performance was unrelated to the presence of mood disorder is consistent with existing views that, to the extent that impaired perceptual sensitivity indexes a neurointegrative deficit, this deficit may be specific to schizophrenia spectrum disorders rather than associated with mood disorders (Cornblatt et al. 1989; Cornblatt and Keilp 1994).

Summary of DS-CPT findings. The DS-CPT protocol operated as a vigilance task, producing rapid decrements in perceptual sensitivity and increases in response bias, with

³⁸ These post hoc groups differed significantly in their summary scores for perceptual sensitivity ($F(3, 187) = 6.55, p < .0003, \eta^2 = .095$); due to the smaller sizes of the high schizotypy groups, follow-up Tukey contrasts were only significant for the comparison of the low schizotypy, high intrinsic motivation and the low schizotypy, low intrinsic motivation groups.

the non-parametric measures of these signal detection indices remaining independent throughout the protocol. Although the motivational inductions did not produce differences in participants' subjective experience as reported in post-experimental questionnaires, these inductions did influence performance significantly in expected directions. The high intrinsic motivation condition attenuated the decrement in perceptual sensitivity, while the low autonomy, "ego-involving" condition increased this decrement, relative to the standard condition. Because participants did not report variations in intrinsic motivation related to the motivational inductions, it may be that the effect of these conditions operated outside participants' awareness. In any case, the intrinsic motivation induction appears to have assisted participants in maintaining higher levels of perceptual sensitivity for longer periods of time.

No effect for either schizophrenia or anhedonia was significant in predicting the rate of decline in perceptual sensitivity. These data therefore do not support the hypothesis that the schizophrenia-related attentional deficit is characterized by a more rapid decline in perceptual sensitivity over time. Although one recent study reported a differentially rapid decline in chronic schizophrenics relative to controls (Nester et al. 1990), most research has not provided evidence for a differential drop in perceptual sensitivity. Instead, the schizophrenia-related attentional impairment appears to be characterized by a consistently depressed level of perceptual sensitivity throughout the protocol (Cornblatt and Erlenmeyer-Kimling 1985; Cornblatt et al. 1989; Nuechterlein 1983; Nuechterlein 1991). These data are consistent with this latter characterization.

Both schizophrenia and anhedonia were found to depress participants' overall levels of perceptual sensitivity. Their interaction indicated that impaired perceptual sensitivity was particularly likely when both dimensions were elevated. These findings may be partially at odds with the view that attentional deficits in schizophrenia are primarily associated with anhedonia-related cognitive capacity limitations (Cornblatt and Keilp 1994;

Nuechterlein 1991). However, the association between positive schizotypy and attentional impairment is consistent with other research with psychometrically identified participants (e.g., Lenzenweger et al. 1991; Obiols et al. 1992). I return to fuller consideration of this issue in the Discussion.

Neither schizophrenia nor anhedonia was found to be associated with participants' response bias. This finding, together with the orthogonality of response bias and perceptual sensitivity, confirm that the schizotypy-related deficit in attentional performance detected in this sample is not the result of poor response strategy. This result is consistent with established findings with schizophrenics and individuals at risk for schizophrenia spectrum disorders, who also show no consistent differences from controls in response bias (e.g., Cornblatt and Keilp 1994).

Three related sets of findings are central to the DS-CPT results. First, participants' intrinsic motivation, positive emotion, and persistence significantly predicted perceptual sensitivity, as did the experimental motivational induction (Figures 16, 18, 17, and 15, respectively). Second, these effects were independent of the effect for schizotypy. That is, there were no interactive or mediating effects between schizotypy and participant engagement in the DS-CPT protocol. Third, participants' level of intrinsic motivation could compensate at least partially for the impaired sensitivity associated with schizotypy (Figure 19). These findings indicate that participant motivation and schizotypal tendencies are independent factors in the prediction of attentional performance, and that attentional performance results from the additive combination of these two factors along with unidentified others.

Finally, mood disorder appeared to have no relationship to perceptual sensitivity with this protocol. Previous research has identified deficits in perceptual sensitivity with depressed participants using an identical pairs CPT. However, these deficits were specific to stimuli composed of random shapes and were not found for numeric stimuli, and

participants were in-patients at a psychiatric hospital and therefore undoubtedly more depressed than the participants included in the current study (Cornblatt et al. 1989). Thus, while the specificity of perceptual sensitivity decrements to schizophrenia-spectrum disorders remains to be fully tested, current findings are consistent with the hypothesis that the perceptual sensitivity impairment found for schizophrenia does not also appear in the case of mood disturbances and depression (Nuechterlein 1991).

Step 5: Interactive Models of Psychopathology

In the final stage of analysis, interactive regression models were tested to predict levels of schizophrenism and anhedonia. Theoretically, these models were based upon the diathesis-stress formulations of schizophrenic disorders, in which neurointegrative vulnerabilities interact with stressful or deficient interpersonal environments to produce increased likelihood of schizophrenia breakdown (Nuechterlein 1987; Nuechterlein and Dawson 1984a; Zupin and Spring 1977). Empirically, these models were intended to replicate findings from pilot work, that attachment and attentional performance interacted to predict levels of schizotypy (Wilson and Costanzo 1995).

Specifically, my earlier findings were that the ability to depend on others factor of adult attachment interacted with overall hit rate on a dynamic CPT to predict anhedonia. This interaction indicated that when both attachment and attentional performance were poor, anhedonic experience increased, but that so long as either attachment or attentional performance was good, there was no increased likelihood of anhedonia. What this finding did not make clear was whether the hit rate scores contributing to the interaction reflected perceptual sensitivity or response bias. For reasons discussed in more detail elsewhere (Wilson and Costanzo 1995), it is inappropriate to use signal detection indices with a dynamic CPT, because this protocol permits detection difficulty to vary from participant to participant. The finding of an attachment x attention interaction was therefore fundamentally ambiguous. It could indicate either an interaction between neurocognitive

vulnerability and interpersonal stress, as hypothesized, or an interaction between response strategy and interpersonal stress. If the former was the case, the interaction was one of the few statistical findings supporting a diathesis-stress model of schizophrenia. However, if the latter was the case, the interaction would have simply signified that anhedonic experience increased as participants became more conservative and possibly less engaged in the dynamic CPT protocol, so long as attachment processes were also impaired. Thus, a conservative response strategy rather than a neurocognitive impairment would have contributed to the prediction of anhedonia.

The applicability of signal detection indices to the current protocol provided a potential opportunity to test these alternative explanations. To model the hypothesized diathesis-stress interaction in the current sample, neurointegrative vulnerability was operationalized by the summary scores for perceptual sensitivity, and stress was operationalized by the global interpersonal factors derived from the Adult Attachment and Mother-Father-Peer scales. To test whether response strategy was the operative factor in my prior findings, the summary scores for response bias were entered into interactions with the interpersonal measures in a separate set of regressions.

Perceptual sensitivity models. None of the attachment x perceptual sensitivity interaction models were significant in predicting either schizophrenia or anhedonia after controlling for lower order effects. For schizophrenism, the interaction between global adult attachment and perceptual sensitivity was nonsignificant ($F(1, 185) = .01, ns$), as was the interaction between global mothering and perceptual sensitivity ($F(1, 185) = .87, ns$), the interaction between global fathering and perceptual sensitivity ($F(1, 185) = .83, ns$), and the interaction between childhood peer acceptance and perceptual sensitivity ($F(1, 185) = 1.26, ns$). Similarly, for anhedonia, the interaction between global adult attachment and perceptual sensitivity was nonsignificant ($F(1, 185) = .10, ns$), as was the interaction between global mothering and perceptual sensitivity ($F(1, 185) = .07, ns$), the

interaction between global fathering and perceptual sensitivity ($F(1, 185) = .45$, ns), and the interaction between childhood peer acceptance and perceptual sensitivity ($F(1, 185) = 1.17$, ns). Thus, there was no evidence from these data of an attachment by attention interaction that predicted schizotypal tendencies.

Response bias models. Similarly, none of the attachment x response bias models were significant in predicting either anhedonia or schizotypy after controlling for lower order effects. For schizophrenism, the interaction between global adult attachment and response bias came closest to significance ($F(1, 185) = 2.58$, $p < .1097$). However, given the large number of models tested here, pursuit of this trend was not warranted. The remaining interactions were clearly nonsignificant: global mothering x response bias ($F(1, 185) = .07$, ns), global fathering x response bias ($F(1, 185) = .65$, ns), and childhood peer acceptance x response bias ($F(1, 185) = .19$, ns). Similarly, for anhedonia, the interaction between global adult attachment and response bias was nonsignificant ($F(1, 185) = 1.01$, ns), as was the interaction between global mothering and response bias ($F(1, 185) = .27$, ns), the interaction between global fathering and response bias ($F(1, 185) = .66$, ns), and the interaction between childhood peer acceptance and response bias ($F(1, 185) = .24$, ns). Thus, there was also no evidence from these data that response strategy on the DS-CPT interacted with interpersonal stress to predict schizotypal tendencies.

Summary and discussion of interactive models. The repeated null results for interaction terms with signal detection indices provide no evidence for the diathesis-stress model hypothesized for schizophrenic disorders. These results also do not corroborate my prior findings of a significant interaction between attachment and hit rate in the prediction of anhedonia (Wilson and Costanzo 1995). Given the inconsistency between current and prior findings, several possibilities remain. First, the difference in findings may have been due to differences in the samples. The sample in my first study was selected for participation in the dynamic CPT based upon their response to Hazan and Shaver's (1987)

attachment instrument, while the current DS-CPT sample was selected based upon their schizotypy scores. However, participants in the Wilson and Costanzo (1995) CPT study had a broad range of anhedonia and schizophrenism scores, as did participants in this study, so it is unlikely that a restricted range of schizophrenism or anhedonia in either sample contributed to the discrepant findings. Participants from both samples that completed the CPT had equivalent ranges in these factors and were drawn from the same population of highly functioning undergraduates.

A second possibility is that the use of different factor scoring techniques in the two studies lead to significant alterations in the metric of measurement for both schizotypy and attachment. In the current study, factor scores were computed, producing normally distributed scores with a mean of zero and a considerable range of scores, while in the first study, observed scale scores were computed, producing a more limited range of scores. Thus, while the two samples may have actually possessed comparable variability in schizotypy and attachment, measurement differences may have resulted in a greater range in the current sample.

Third, it is possible that the interaction between attachment and hit rate in the first study may have been the result of sampling error. The current DS-CPT sample is almost four times larger than the previous sample completing the dynamic CPT, and any robust interactive effect should have been detected. However, this possibility is unlikely, because the dynamic CPT sample was relatively large and drawn from the same population as the current sample.

The fourth and perhaps most likely possibility is that the discrepant findings may be due to differences in the CPT protocols. That is, the interaction between attachment and hit rate found in Wilson and Costanzo (1995) may have been specific to the particular parameters of the dynamic CPT protocol, parameters that were not replicated with the DS-CPT. For instance, the dynamic CPT has much shorter ISIs, longer stimulus

presentations, and entails a heavier memory load than does the DS-CPT. More generally, participants in the current study informally reported the DS-CPT to be highly taxing, while participants in the first study often indicated that the dynamic CPT was boring. If it is the case that the dynamic CPT was substantially easier than the DS-CPT, then poor performance on the dynamic CPT may be highly indicative of neurocognitive difficulties. Those participants who performed poorly on this task would then be highly prone to psychopathology, and supportive attachments would be crucial in protecting a subset from psychopathology. Thus, the attachment-attention interaction in Wilson and Costanzo (1995) may have been carried by a small number of participants.

By contrast, because of the difficulty level of the DS-CPT, participants in the current study had a greater range of attentional performance, and ceiling effects were substantially reduced. Therefore, the DS-CPT may measure the relationship between attention and psychopathology in a more linear fashion than did the dynamic CPT. This linear relationship may account for much the variance that was captured in the attention-attachment interaction for the easier CPT. Alternatively, because of the difficulty level of the DS-CPT, other proximal factors (such as motivation) may have "drowned out" the more distal factor of adult attachment. Indeed, because motivation did have a main effect in predicting DS-CPT scores, poor performance on the DS-CPT was not a pure measure of neurocognitive disability; participants could perform poorly because of poor motivation, presence of schizotypy, or both. So, while the difficulty level of the DS-CPT makes the protocol more sensitive to variations in attentional performance than is the dynamic CPT, this same sensitivity may also allow operation of other factors in performance, and thus blur the investigation of the diathesis-stress model.

I am in the process of re-analyzing the Wilson and Costanzo (1995) data based upon current findings and the foregoing considerations. Although I do not treat this topic further here, I do not believe the lack of interactions in the current study poses a substantial

threat to diathesis-stress models of psychopathology. Detection of buffering and risk interactions in developmental psychopathology is exceedingly difficult, both from a measurement and from a modelling standpoint. This difficulty may be a contributing factor to the lack of research attempting to investigate stress, vulnerability, and buffering factors from a systemic perspective. However, I believe Wilson and Costanzo (1995) and the current study are important attempts to make headway in this area. Identification of measures that do reflect interactions between chronic vulnerabilities and psychosocial factors will go far in shedding light on the developmental processes that can lead to schizophrenic disorders.

DISCUSSION

Key findings reported above may be gathered under two broad headings. The first concerns the findings related to attachment, and in particular how interpersonal measures are related to schizotypy. The second concerns the findings related to schizotypy, attention, and motivation. In both areas there are important methodological and conceptual issues to address.

Attachment Findings

Attachment styles. Findings with the current sample largely replicate those found with the pilot sample (Wilson and Costanzo 1995). Participants assorted themselves into the three classical attachment styles in proportions comparable to those reported in other studies (Collins and Read 1990a; Feeney and Noller 1990; Hazan and Shaver 1987, 1990; Wilson and Costanzo 1995). However, the three groups derived from exploratory cluster analysis provided only ambiguous support for the trichotomous division of attachment. Due to the large size of the sample, failure to obtain convincing corroboration of the

existence of three discrete attachment styles raises the larger issue of the external validity of these categories.

Evidence is now accumulating that attachment may be partitioned most parsimoniously into four, rather than three, major styles (e.g., Bartholomew and Horowitz 1991; Feeney et al. 1994). This four-category system emerged largely to account for discrepancies in how avoidant attachment was characterized in self-report and interview methodologies. In the former method avoidant attachment was characterized by low self-esteem and awareness of interpersonal difficulties, while in the latter method it was characterized by defensively high self-esteem and denial of interpersonal difficulties. The four-category system accounts for this discrepancy by retaining the secure and anxious-ambivalent (renamed "preoccupied") categories, but splitting the avoidant category into dismissive-avoidant attachment and fearful-avoidant attachment. The latter category may be related to Main's category D in the infant attachment literature, characterized by disorganized and unresolved attachment behavior (Brennan, Shaver, and Tobey 1991; Main and Cassidy 1988).

The resulting four categories can be mapped onto two underlying dimensions corresponding to the secure-fearful spectrum and the preoccupied-dismissive spectrum. This system brings clarity to the adult attachment literature. The underlying working models of self and other that characterize attachment styles are aligned along the two dimensions into the four possible combinations of (a) positive models of both self and other (secure attachment), (b) negative model of self and positive model of other (anxious or preoccupied attachment), (c) positive model of self and negative model of other (avoidant-dismissive attachment), and (d) negative model of self and negative model of other (avoidant-fearful attachment) (Bartholomew and Horowitz 1991; Brennan et al. 1991).

At the present time the number and status of attachment style categories has depended primarily on methodological and theoretical differences (for a recent review see Rothbard and Shaver 1994). More rigorous confirmation of discrete styles is needed than can be provided by exploratory cluster analysis conducted on individual measures. Using this method Feeney et al. (1994) found four clusters corresponding to the four-category scheme reviewed above; with the same method but a different instrument Collins and Read (1990a) and Wilson and Costanzo (1995) found three clusters corresponding to the classic three-category scheme. In the present study, there was ambiguous evidence of a three-cluster solution, but also partial evidence for two- and four-cluster solutions. The two-cluster solution separated participants into broad categories of secure and insecure attachment, and the four-cluster solution approximated the four-quadrant division of attachment described above (footnote 18). Multimethod assessment of attachment, such as that used in Bartholomew and Horowitz's (1991) study, will be essential to clarify this issue.

Method variance is particularly important to consider in relation to the absence of sex differences in attachment found for this sample. Although three-category self-report measures of attachment style are consistent across studies in revealing no sex differences, this is not the case with four-category self-report measures, even within the same sample (Brennan et al. 1991), or with interview methods (e.g., Bartholomew and Horowitz 1991; Kobak and Sceery 1988). Instead, these methods reveal that more of the anxiously attached participants are female than male, while the reverse is true for dismissive-avoidant attachment. Clearly, assessment of method variance and resolution of these disparate findings is an important direction for future attachment research. It is an empirical question whether discrete and stable styles of attachment exist, and if so, how they should best be characterized. At the present time these issues remain unresolved (Berman and Sperling 1994). Taxometric analysis (e.g., Meehl 1995) may be helpful in this regard.

Attachment and schizotypy. The substantial relationship found here between schizophrenia and insecure attachment replicates my prior findings (Wilson and Costanzo 1995) and is consistent with preliminary evidence that schizotypal personality disorder is associated with anxious attachment (reviewed by West and Keller 1994). Despite a somewhat different confirmatory factor solution than that obtained in the pilot study, and the use of rated rather than dichotomous items to comprise the schizotypy measure, the size of the schizophrenia-attachment relationship was similar across studies. In my original sample, the effect size across attachment style groups was $\underline{d} = .5467$, and across the three-cluster solution it was $\underline{d} = .7700$ (Wilson and Costanzo 1995); in the current sample, these figures are $\underline{d} = .4676$ and $\underline{d} = .8023$, respectively. These consistencies begin to provide evidence for the robustness of the findings.

As pointed out previously and supported by path modelling, the relationship between adult attachment and schizophrenia is likely to be bidirectional. There is now abundant evidence that disturbances in surrounding interpersonal relations become more likely as the cognitive and perceptual disruptions associated with schizotypy intensify, while schizotypal disturbances grow more likely as interpersonal relationships become difficult (Gottesman 1991; Mishler and Waxler 1968; Leff and Vaughn 1985; Nuechterlein et al. 1989; Wilson and Costanzo 1995). Permitting the direction of effects to go in both directions in the path models did not diminish the goodness of fit in the model for either males or females, and it also captured a greater percentage of the variance in adult attachment. Although constraining the path coefficients in both directions to be of equal weight represented an a priori approximation to real world dynamics, to my knowledge there is no evidence to suggest that one direction should be given greater weight over the other. In sum, these components of the path models are consistent with empirical evidence, common sense, and covariance fit indices.

The results failed to replicate prior findings that anhedonia was substantially associated with avoidant attachment (Wilson and Costanzo 1995). One partial explanation for this discrepancy stems from the difference in the anhedonia measures used in the two studies. In my first study, the anhedonia measure contained a number of items indexing social anhedonia. Because social anhedonia and avoidant attachment share the common feature of minimizing interpersonal relationships, it was to be expected that a relationship between the two dimensions emerged (Wilson and Costanzo 1995). By contrast, the anhedonia measure in the present study referred almost entirely to deficits in physical rather than social pleasures, and this difference may have attenuated the relationship between anhedonia and attachment.

However, substantial relationships between a very similar measure of physical anhedonia and both impaired social competence and interpersonal avoidance have been reported previously (Haberman, Chapman, Numbers, and McFall 1979; Numbers and Chapman 1982). Chronic physical anhedonia may reflect the absence of positive reinforcers that support social interactions (Meehl, 1975/1987). Although the trend found in the current sample for avoidantly attached participants to report higher levels of anhedonia is consistent with these findings, the effect was much diminished. Reasons for this difference are not immediately discernable from the data.

Path analyses confirmed and extended the finding of a substantial relationship between attachment and positive schizotypy but not negative schizotypy. Several features of the path models are worthy of comment. First, the bidirectionality between adult attachment and schizophrenia has already been underscored. It is important to note the somewhat smaller relationship between adult attachment and schizophrenia for females compared to males. The attenuation of this relation may be due to gender-specific socialization that supports and channels women more than men towards social connectedness. As a result of this socialization, women may remain relatively better

attached even if experiencing schizotypal tendencies, so that the presence of schizotypal tendencies is not as closely linked to impaired attachment for women as it is for men.

Research on gender socialization and schizophrenia spectrum disorders is an important task for the future; the present findings are broadly consistent with reports of superior social competence among female schizophrenic patients compared to male schizophrenics (e.g., Andia and Zisook 1991).

Second, it is clear that impaired interpersonal relations alone do not suffice to produce schizophrenic disturbances, if only because impaired interpersonal relations are far more common than schizophrenic disorders (Goldstein 1990; Gottesman 1991). However, to the extent that impaired interpersonal relations do contribute to schizotypal tendencies, it is important to recognize that the effects are likely complex. For instance, the finding in the current samples that adult attachment mediates the relationship between schizophrenism and relationships with parents suggests that a simple "schizophrenogenic" model positing impervious, rejecting, and disconfirming parents as direct etiological agents (i.e., main effects) in the development of schizophrenia spectrum disorders may be a great oversimplification. The mediating effect of adult attachment shown in the path solutions is more consistent with a model that posits multiple factors incrementally and interactively accumulating to produce compromised attachment in the young adult, and this compromised attachment in turn contributes to schizotypal tendencies. Complex non-linear combinations of stressors in the context of an enduring biological vulnerability probably more accurately characterize the genesis of schizophrenic disorders (Carson and Sanislow 1993; see Rutter [1990] for a discussion of complex interactions in developmental psychopathology).

Third, the relationships between recalled childhood attachments with peers and parents may also be considerably oversimplified in the path models. Just as a culmination of interactions may contribute to schizophrenic disordering, so an accumulation of

interpersonal experiences likely contributes to the formation and modification of enduring attachment styles over time (Rothbard and Shaver 1994). Given multiple contributors to attachment over childhood, second- and third-order interactions between parent and peer attachments are worth investigating. Although difficult to model in real time, these interactive dynamics may prove more powerful predictors of stable attachment than the simple linear effects shown in the path models. In the present case, the retrospective data are limited (e.g., may reflect response bias and the current status of relations with attachment figures). Future longitudinal research is required to identify and partition the causal links contributing to stable adult attachment traits (Rothbard and Shaver 1994).

Fourth, for females there was a striking absence of significant effects for maternal relations in childhood on either adult attachment or schizophrenism, while a relatively small effect was found for anhedonia (Figures 9 and 11). In addition, the effect of paternal relations in childhood on adult attachment was larger for females than for males. Absence of a path from the maternal relations variable to adult attachment in females was not a function of a restricted or highly skewed range (the distributions for males and females were approximately the same) or a result of increased collinearity (correlations among the mother, father, and peer scales were similar across sex).

One possible explanation for these findings is that the female participants in this study, like their male counterparts, are generally very high functioning, very high achieving individuals; males and females did not differ on achievement orientation (footnote 22). It may be that, for females, high achievement orientation is associated with particularly strong identification with and attachment to fathers, and that these relationships eclipsed the contributions that mothers made to female participants' adult attachment. Alternatively, the relationship between maternal relations and adult attachment may have been attenuated for female participants because these young women perceived the nurturance they recalled receiving from their mothers as primarily gender role-driven rather than self-relevant. Male

participants, who largely have not been recipients of gender-specific socialization that emphasizes nurturance as a female role, might be less likely to discount maternal relations as role-driven rather than self-relevant. However, these explanations must remain speculative in the absence of careful research investigating the relationship between gender roles and the development of attachment. This domain of inquiry has been neglected, as recently noted by Putallaz, Costanzo, and Klein (1993). The data reported here and data now being collected from the parents of the current participants may begin to provide a clearer view of the relationships between gender and attachment.

Fifth and finally, the potent effects of recalled childhood peer relations are particularly noteworthy. As mentioned earlier, these were an order of magnitude larger than the effects for recalled attachment to parents during childhood, and as indicated in Figures 9 and 10, both direct and indirect paths were contributory. Again, these findings suggest that childhood relationships with parents are not the only, or perhaps even the primary, domain of psychosocial stress contributing to schizotypal tendencies. Because the measures were retrospective self-reports, the data are ambiguous in terms of the direction of effects. Moreover, the simplified models do not reflect any impact that relations with parents may have had on childhood peer relationships. However, the large total effects for childhood peer attachment in the prediction of schizophrenia are broadly consistent with Sullivan's (1940, 1953) emphasis on the corrective influence of peer relationships in preventing psychopathology, and with empirical evidence that disruptions in childhood peer relations may predict later psychopathology (e.g., Shwartzman, Ledingham, and Serbin 1985; Watt, Anthony, Wynne, and Rolf 1984).

Attachment and attention. No association between attachment and attentional performance was detected, using either growth curve analysis or a MANOVA with the summary DS-CPT scores as outcome variables. These findings replicate those of the first study (Wilson and Costanzo 1995) and provide partial confirmation that attentional

performance is not directly related to the quality of attachment relationships. Although qualified by the pronounced effect of motivation on attentional performance (discussed below), these data are consistent with the interpretation of attentional deficits as heritable neurocognitive traits rather than products of impaired interpersonal relationships.

Previous studies reporting a relationship between impairments in attachment and attention in children (Erikson et al. 1985; Jacobson et al. 1994) may reflect attentional impairments more closely associated with Attention Deficit Disorder than with schizophrenia spectrum disorders. These two patterns of attentional deficits appear to be largely unrelated, with the Attention Deficit Disorder pattern generally found to be characterized by impulsive response style (low B") rather than poor perceptual sensitivity (Nuechterlein 1983, 1987). With the young adults in the current study, no relationship emerged to support a connection between impulsive responding and impaired attachment. Given the distal relationship of the attachment measures used here to the early interpersonal dynamics that may be related to impulsive attentional responding, it may not be surprising that no link between attachment and response bias was detected.

There remains the possibility that, early in development, interpersonal dynamics influence not only response style but also perceptual sensitivity. Parental socialization of infants' attentional processes has been captured in investigations on social referencing. This research indicates that parental emotional vocalizations and facial responses modulate infant attention (Feinman 1983; Hornik and Gunnar 1988; Klinnert, Emde, Butterfield, and Campos 1986; Vibbert and Bornstein 1989; Walden and Baxter 1989; Walden and Ogan 1988). Parent communication of security to the infant therefore may coincide with the establishment of attentional processes in the infant. Indeed, confident attention to and exploration of the environment is a defining feature of secure attachment (Ainsworth, Blehar, Waters, and Wall 1978). How this relation between the provision of secure attachment and infant attention is best characterized (e.g., the directionality of the effects),

and whether it proves to be significant in predicting later psychopathology, remains to be investigated. Data from both the current and my pilot study indicate that an attachment-attention relationship, even if significant in early childhood, is not robust with the measurements used with the young adult sample.

Attachment, mood disorder, schizotypy, and attention. A very large association between attachment and a history of mood disorders was found. In turn, presence of mood disorders was associated with heightened levels of schizophrenism but not anhedonia. The heightened rate of mood disorder in insecurely attached individuals is consistent with prior work (Bowlby 1980; Diamond and Blatt 1994), as is the relation between schizophrenism and depression (Allen et al. 1987) and the absence of a relation between anhedonia and depression (Chapman and Chapman 1987). In their 1987 report, the Chapmans interpreted the lack of association between anhedonia and depression to indicate that high anhedonic college students may experience invariant levels of pleasure deprivation, while depressive episodes in non-anhedonic individuals may be marked by temporary, salient drops in hedonic capacity. A similar explanation may account for the findings here.

Although the relationship between mood disorder and attachment was one of the largest effects I report, the subsample of mood disordered participants was relatively small and, moreover, heterogeneous. These characteristics of the subsample may have contributed to the absence of a relationship between mood disorder and attention. However, the absence of this relationship is consistent with prior findings using the identical pairs CPT with numerical stimuli (Cornblatt et al. 1989). Because depression may be associated with diminished neuromotor speed, it is an open question whether depression might effect performance on a CPT protocol that is motorically more demanding, such as the fast-paced dynamic CPT.

Finally, the direction of effects for the attachment-mood disorder and schizophrenism-mood disorder relationships cannot be elucidated from the data. It is

plausible that chronically impaired attachment leads to higher propensities towards both depression and schizophrenism. However, it is equally plausible that depression and schizophrenism might either singly or interactively lead to an impaired ability to form and maintain secure relationships. Longitudinal research with a much larger sample will be needed before these relationships can be sorted out.

Schizotypy, Attention, and Motivation Findings

Schizotypy and perceptual sensitivity. In the current DS-CPT sample, both schizophrenism and anhedonia were found to be significantly associated with diminished perceptual sensitivity. The significant first-order interaction between these dimensions indicated that diminished perceptual sensitivity was most likely when both schizophrenism and anhedonia were elevated; this interaction replicates the significant schizophrenism x anhedonia interaction predictive of hit rate in my dynamic CPT study (Wilson and Costanzo 1995). The deficit was not associated with a more rapid decline in perceptual sensitivity with time, but instead with lowered levels of perceptual sensitivity throughout the task. The impairment in perceptual sensitivity appeared to be independent of the experimental manipulation of participant engagement in the DS-CPT, and of all participant measures of motivation, effort, and emotion. It also appeared to be specific to schizotypy rather than characteristic of more general psychopathology. This effect was somewhat larger than but generally consistent with those reported for other psychometrically identified participants with schizotypal tendencies. Several of the findings associated with these results deserve consideration.

Anhedonia, schizophrenism, and perceptual sensitivity. Identification of the schizophrenism by anhedonia interaction confirmed expectations that both dimensions were related to poor perceptual sensitivity. Anhedonia and other negative symptomatology have consistently been found to contribute to poor attentional performance (Cornblatt and Keilp

1994; Nuechterlein 1991; Wilson and Costanzo 1995), as has positive symptomatology (Lenzenweger et al. 1989; Nuechterlein et al. 1986; Wilson and Costanzo 1995).

Identification of the specific contributions that positive and negative schizotypy make to impaired perceptual sensitivity will require careful examination of the components of attentional processes involved in CPT protocols, systematic variation of CPT parameters, and multiple methods for assessing the positive and negative dimensions of schizotypy. All of these factors are likely to affect the specific associations between schizotypy and attentional impairments that have been reported, and it may be that different components of attention interact with specific task parameters to produce relationships between impaired performance and either negative or positive aspects of schizotypy. For instance, the motoric component of attentional response, which is heavily involved in CPT protocols using very rapid ISIs, may be more closely related to anhedonia than to positive schizotypal disturbances. This conjecture is consistent with earlier findings using a rapid, dynamically based CPT (Wilson and Costanzo 1995) and with the research reviewed earlier linking impaired attentional performance to neuromotor deficits. In contrast, extraction and recognition of stimuli features, attentional components that were heavily involved in the DS-CPT, may be more closely associated with positive schizotypy. Because motoric and feature extraction demands are made by both the dynamic CPT and the DS-CPT, one might expect both anhedonia and schizophrenia to contribute to performance. However, the relative contributions of these dimensions may be different in the two versions of the CPT.

Careful consideration of the DS-CPT parameters indicates that motor skill was not heavily taxed or essential to good signal detection. Stimuli were presented once every second for 40 msec, leaving 960 msec for participants to respond when the stimulus was a target, before the next stimulus appeared. On average, participants responded in 497 msec (range: 399 - 737 msec), leaving something close to half a second to spare. Thus, the most plausible explanation for the strong association between high perceptual sensitivity

and short reaction times is that rapid reaction times are more likely in the DS-CPT when participants are better at distinguishing stimuli, not that perceptual sensitivity is more likely when reaction times are rapid. Participants easily responded within the 960 msec limit if they responded at all to a stimulus, so perceptual sensitivity did not require rapid reaction time within that limit.

The conditional relationship between perceptual sensitivity and response time is reversed when the ISI is reduced to durations that approach the limits of participants' ability to respond rapidly. This is the case with the dynamic, response-driven CPT, which typically involves ISIs of some 400 to 500 msec (Buchsbaum and Sotek 1980; Wilson and Costanzo 1995). The stimuli themselves are neither degraded nor presented for periods just over threshold levels of detectability, and therefore place less demand on the perceptual components of attention than does the DS-CPT. Rather, rapid reaction times are essential for perceptual sensitivity in the dynamic CPT; impaired motor proficiency will lead to fewer detections being recorded and thus to lower levels of perceptual sensitivity. Therefore both attentional and neuromotor deficits are likely to contribute to poor performance on this protocol. If impaired neuromotor functioning is related to negative schizotypy, one might expect anhedonia to contribute to impaired performance to a greater extent than schizophrenism in the dynamic CPT, while expecting schizophrenism to contribute to a greater extent than anhedonia in the DS-CPT. The cumulative findings from the two studies indeed suggest this may be the case. Although significant schizophrenism x anhedonia interactions were found in both studies, the main effect for anhedonia, not for schizophrenism, was significant in predicting attentional performance in the dynamic CPT study (Wilson and Costanzo 1995), while the reverse was true for the current study.

This line of reasoning does not address the association between impaired perceptual sensitivity and negative symptomatology found with overtly schizophrenic patients (Cornblatt and Keilp 1994; Erlenmeyer-Kimling et al. 1993; Nuechterlein et al. 1986).

However, there is no evidence that vigilance impairments are exclusively associated with negative symptoms, and at least four studies indicate an association between impaired sensitivity and formal thought disorder (Nuechterlein et al. 1986), positive symptomatology (Nestor et al. 1990; Obiols et al. 1992), or a mix of positive and negative symptoms (Nestor et al. 1990; Wilson and Costanzo 1995). Standardization of CPT protocols (Nuechterlein 1991) and fine-grained exploration of the relationships between symptomatology and attentional impairment will need to be accomplished before a coherent picture can emerge.

At a more general level, the dichotomy between negative and positive symptomatology, along which recent schizotypy and schizophrenia research has proceeded (Vollema and van den Bosch 1995), may itself need to be rethought. Although self-report data indicate that these are separate, negatively correlated dimensions in schizotypy, and research with schizophrenics indicates the dimensions are largely independent in overt schizophrenia, many schizophrenics nevertheless experience both types of symptoms (Guelfi, Faustman, and Csernansky 1989). Although they are negatively correlated with each other in college populations, both negative and positive schizotypal tendencies are positively correlated with other measures of psychosis proneness, such as heightened 2-7-8 and 2-7-8-0 profiles on the Minnesota Multiphasic Personality Inventory (Chapman et al. 1982). Very high levels of physical anhedonia are also associated with greater thought disorder as assessed by Rorschach protocols (Edell and Chapman 1979). Judging by phenomenological reports (J. Chapman 1966; Sullivan 1940, 1953), extreme withdrawal and overactivation can occur simultaneously in complex feedback loops.

Thus the difficulty of partitioning and measuring these aspects of schizophrenia symptomatology, and the risk of oversimplifying the symptom picture with "positive-negative" distinctions, should not be underestimated. Little is known about how the relationship between these dimensions may change as psychopathology intensifies, in

either an intraindividual or an interindividual sense. The picture that emerges from this study and from my pilot investigation, both with reasonably high-functioning participants, is that a synergistic effect between positive and negative schizotypy is related to poor attention. Future CPT investigations should continue to test for this interaction.

Motivation, schizotypy, and attentional performance. Central to the DS-CPT results are three new and highly noteworthy sets of findings. First, participants' intrinsic motivation, positive emotion, and persistence significantly predicted perceptual sensitivity. This effect was most substantial for intrinsic motivation, which accounted for fully 11% of the variance in overall perceptual sensitivity; converted to d using Hunter and Schmidt's (1990, p. 272) formula, this amounted to an effect size of .7135.

These results challenge the prevailing view in CPT research that perceptual sensitivity is independent of participants' motivation. Because perceptual sensitivity was increased by the intrinsic motivation induction, by participants' levels of persistence, and by participants' positive emotional tone, there can be little doubt that motivated engagement in the protocol will affect performance measures. The accumulation of significant findings with these multiple measures of engagement constitute within-study replications; these replications are all the more noteworthy because the predictor variables (global intrinsic motivation, persistence, and global positive emotion) were largely non-redundant. Taken broadly, each of these participant variables can be considered as an aspect of what Csikszentmihalyi (1990) has termed "flow," or the experience of being effortfully engaged in self-determined activity that challenges and interests us and absorbs our attention. The data thus provided convergent evidence that motivated absorption improved attentional performance.

Equally striking is the second set of novel findings, that motivational factors did not interact with schizotypy to predict perceptual sensitivity. The experimental manipulation of increasing motivation set through the intrinsic motivational induction did not reduce the

difference between high and low schizotypy participants, while the low autonomy induction did not increase it. This schizotypy-related difference was also independent of self-reported levels of intrinsic motivation and emotion, and observed levels of effortful persistence. Consistent findings with largely non-redundant measures again provide convergent evidence that the impairment in perceptual sensitivity shown by high schizotypy participants is *not* mediated by motivational factors. The effect for schizotypy was small compared to that for intrinsic motivation (accounting for 3% versus 11% of the variance in overall perceptual sensitivity, respectively); however, given that $d = .473$, the effect size for schizotypy was actually somewhat larger than those computed from other studies with psychometrically identified schizotypal samples ($d = .392$, Lenzenweger et al. 1991; $d = .360$, Obiols et al. 1992). Thus, although perceptual sensitivity is related to motivation and participant engagement, the impaired perceptual sensitivity associated with schizotypy appears to be unrelated to either response strategy or motivation.

The third set of findings, that increased intrinsic motivation can partially offset the independent schizotypal deficit in perceptual sensitivity, provides a new picture of the group differences in attentional performance that have been reported in the schizophrenia literature. Reports that only a subgroup of at-risk or schizophrenic participants show impaired perceptual sensitivity may lead researchers to conclude that attentional anomalies are characteristic of only certain strains of schizophrenic disorders. The data reported here suggest an alternative explanation. Participant motivation appears to have a large effect on perceptual sensitivity and may partially account for differences in subgroups of index populations. Two potentially important implications flow from this finding. First, if they are masked by high levels of participant motivation, attentional impairments in at-risk and schizophrenic participants may go undetected and be more common than previously reported. Conversely, motivational impairments may be misdiagnosed as chronic attentional deficits. Second, levels of attentional performance per se should not be used to

identify participants as schizophrenia-prone. Impaired perceptual sensitivity is constituted (at the least) by the additive effects of schizophrenia vulnerability and intrinsic motivation, and the variance accounted for by these factors must be partitioned before inferring schizophrenia vulnerability from attentional data.

Future schizophrenia research with the CPT should therefore include measures of participant motivation in order to address these implications systematically. Although no relationship was found between motivation and schizotypy in the current sample, it may be an error to generalize this null finding to participants with more extreme levels of psychopathology. Common sense indicates that individuals in the midst of acute schizophrenia episodes may feel their time is better spent on activities other than a CPT protocol. Thus it may be only within the normative ranges of human experience -- those measured in the current study -- that schizotypy and motivation are independent. Motivational effects may be more complicated as the level of schizophrenic disturbance increases.

The same caution applies to the lack of an interaction between motivational induction condition and schizotypy found with this sample. It might be an error to expect experimental induction and level of schizophrenia symptomatology *not* to interact in samples of more disturbed patients and controls. In the present sample, absence of an interaction indicated that increasing intrinsic motivation through appropriate orientation to the task was equally effective in diminishing the vigilance decrement for high and low schizotypy participants. This suggests that motivational interventions may result in important changes in attentional performance, even among participants with chronic neurocognitive deficits. However, in-patient institutional settings typically establish a context that is far more self-relevant than the context in which undergraduate participants complete psychology experiments. That is, the CPT protocol itself will likely have more importance and personalized meaning to a hospitalized acute schizophrenic than to a college

student. Thus, manipulations in the presentation of the CPT protocol may have larger and more complex effects for schizophrenics than emerged here.

In the current sample, the three motivational induction manipulations failed to produce a significant difference in self-reported intrinsic motivation. The lack of significant differences in self-reported intrinsic motivation across the three conditions is troublesome. I have already suggested that the impact of the motivational inductions may have taken place outside of participants' awareness. For these undergraduates, the challenging and highly salient nature of the DS-CPT may have eclipsed at a conscious level the impact of the motivational inductions employed here. In contrast, in the Deci et al. (1994) study in which motivation manipulations produced significant differences in undergraduate participants' levels of intrinsic motivation, the vigilance task was "boring" and probably less salient to the participants. The relative intensity of the tasks following motivational inductions may therefore mediate the degree to which participants report their sense of intrinsic motivation based upon the task rather than the induction.

Growth curve analysis. Finally, the advantages of using growth curve analysis to model the DS-CPT data should not go without comment. Compared to simple regression using summary scores, growth curve analysis detected many more significant relationships. These relationships emerged in part because growth curve modelling took full advantage of the repeated measures data, and in part because the use of a mixed model permitted the error term to be more precisely partitioned into three separate components -- individuals' deviation from a simple linear relation with time, their deviation from a group-specific intercept term, and their deviation from a group-specific slope term. In turn, these features of the analyses focused research questions not just on overall perceptual sensitivity levels, but also on change over time. Such a focus is entirely appropriate to vigilance tasks such as the CPT, where the traditional measure of vigilance is the drop in perceptual sensitivity over time. The power of the technique was illustrated by the findings that

important differences in the decrease in perceptual sensitivity due to the motivational inductions showed up only as trends in the simple ANOVAs, but were highly significant in the growth curve models. The closer look afforded by growth curve modelling also permitted careful analysis of the components of attentional performance and schizotypy. Future researchers using the CPT and other vigilance tests are encouraged to take full advantage of this technique, rather than discarding time-specific data in favor of global summary scores.

Concluding Remarks

Although the effect for schizotypy on DS-CPT performance was of similar magnitude to those reported for other psychometrically identified individuals, and although the schizotypy measure used in this study was quite similar to those from which it was derived (Venables et al. 1990), it should be noted that the specific schizotypy measure employed here has not been validated with schizophrenic samples. Moreover, the sample in this study, like that in Wilson and Costanzo (1995), was generally very highly functioning. Therefore, caution should be used in generalizing current findings to more overtly disturbed populations.

Such caution is particularly warranted given accumulating evidence of a latent schizotypy taxon (Korfine and Lenzenweger 1995; Lenzenweger and Korfine 1992; Lenzenweger and Molden 1990; Molden, Gottesman, and Erlenmeyer-Kimling 1987; Molden, Gottesman, Erlenmeyer-Kimling, and Comblatt 1990; Tyrka et al. 1995). This line of research provides empirical support for the existence of a distinct class of individuals with significantly increased schizotypal tendencies, much as Meehl (1990) theorizes to exist. As such, it represents a challenge to the view that schizophrenia comprises a continuum of psychotic disordering (e.g., Venables et al. 1990; Vollema and van den Bosch 1995). Meehl's (1995) recent summary of taxometric analysis provides an excellent discussion of how dimensional measures of a symptom (e.g., schizophrenia, or

body temperature) may be normally distributed in the population and yet index a latent taxon with relatively clear boundaries (e.g., schizotypy, or the presence of a specific pathogenic organism in the body). The taxometric analyses with at-risk populations cited above suggest that schizotypy is dichotomously distributed in the population, and that only the indicators of the taxon are continuous.

In the present case, no taxometric analyses were conducted on the schizotypy measures. This leaves open the possibility that the important relationships identified here actually represent a commingling of effects detected from two or more distinct populations, only one of which may be positive for the schizotypy taxon. In the absence of such analyses, it is unclear how the findings reported here may apply to more disturbed schizophrenics. I have already noted some speculations regarding changes in the relationship between motivation and attention as the level of schizophrenic disturbance intensifies. However, if the relationships that emerged in my analyses are relevant to schizophrenia spectrum disorders, three key implications follow.

First, as already underscored, measures of motivation should be included in future CPT research with schizophrenics. Although it is unclear what percentage of the perceptual sensitivity decrement is due to poor motivation in schizophrenics, the current data suggest that this percentage is not negligible and may be quite sizeable. With the current sample, the effect for motivation was larger than that for schizotypy; it may be that this ratio is substantially altered in overtly schizophrenic samples.

Second, it may be possible to increase schizophrenics' perceptual sensitivity scores by increasing their sense of flow (Csikszentmihalyi 1990) or intrinsic motivation (Deci and Ryan 1985) while engaged in the CPT protocol. In general, this could be accomplished through modifications of the motivational inductions used in the current study. It may be of particular importance to reduce schizophrenic participants' sense that they were being tested because something was wrong with them, or that their performance was intimately

connected with their psychiatric status. These concerns operate to obstruct flow and may contribute to impaired perceptual sensitivity. Although no improvement in initial or overall perceptual sensitivity was found in the current sample with such inductions, it was possible to reduce the vigilance decrement. It is an empirical question whether such effects are possible with more disturbed participants.

This approach to orienting schizophrenic participants to experimental protocols is broadly comparable to recent work by Green and his colleagues (Green et al. 1990; Green et al. 1992; Liberman and Green 1992). These researchers found that, with proper instructional and motivational orientations, schizophrenics' deficits in Wisconsin Card Sort protocols were effectively eliminated. In a recent study, schizophrenics first completed the DS-CPT and then were trained extensively on non-CPT vigilance tasks. Following training, they again completed the DS-CPT; results provided ambiguous evidence that the drop-off in perceptual sensitivity on the DS-CPT could be reduced (Benedict et al. 1994). Small sample size and statistical difficulties qualified this finding, and the authors concluded that training was ineffective in improving CPT performance (Benedict et al. 1994). However, training was conducted on tasks other than the DS-CPT, and it is unclear from the description of the training whether intrinsic motivation inductions were included. In addition, the possible diminution of the vigilance decrement they detected is quite similar to the effect found for the intrinsic motivation induction in the current study. Future research should examine whether appropriate training that includes motivational orientations designed to increase flow can improve schizophrenics' CPT performance levels.

Third and finally, such motivational interventions with CPT research may also serve as an important component of therapeutic interventions with schizophrenics. If levels of motivation can be raised sufficiently to improve perceptual sensitivity, this may have important clinical implications. DS-CPT-assessed perceptual sensitivity has recently been

found to be strongly related to interpersonal skills and response to social skills training in schizophrenics (Bowen et al. 1994). If components of attentional performance act as building blocks for the more complex cognitive processes involved in interpersonal exchanges and social skills training, as Bowen et al. (1994) suggest, improvement in attention may flow "upwards" to higher-order cognitive processes. Such an effect could then have considerable implications for a schizophrenic's quality of life.

APPENDIX A

Original Studies with the Continuous Performance Test (CPT)

Relevant to Schizophrenia Research

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
1. Rosvold, Mirsky, Sarason, Bransome, and Becks 1956	73 brain-damaged Ss, 94 non-brain-damaged Ss	Revolving drum with viewing window	X, A-X	None	920
2. Kornetsky and Orzack 1964	7 normal Ss	Lindsely Manipulum Board	X	None	1000
3. Latz and Kornetsky 1965	8 unmedicated male chronic schizophrenics	Lindsely Manipulum Board	X	None	1000
4. Orzack and Kornetsky 1966	16 unmedicated chronic schizophrenics	Lindsely Manipulum Board	X	None	1000
5. Orzack, Kornetsky, and Freeman 1967	18 unmedicated chronic schizophrenics	Lindsely Manipulum Board	O	None	1000
6. Wohlberg and Kornetsky 1973	16 unmedicated remitted female schizophrenics	Lindsely Manipulum Board	5-9	Simultaneous strobe and metronome	950
7. Orzack and Kornetsky 1971	27 unmedicated, 42 medicated chronic schizophrenics	Lindsely Manipulum Board	O	None	1000
8. Grunebaum, Weiss, Gallant, and Cohler 1974	20 5-year-old high-risk Ss, 13 6-year-old high-risk Ss, equal numbers of controls, and their mothers	NR	the color red for 5-year-olds, X for 6-year-olds	None	NR
9. Asarnow, Steffy, MacCrimmon, and Cleghorn 1977***	9 high-risk Ss, 10 foster controls Ss, 10 community controls	Tachistoscopic visual display	7	None	1100

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
NR	310 stimuli, or about 5 mins	25.8% (X), 19.4% (A-X)	None	Hit rate, hit rate/ all responses
100	4 minutes	20%	None	Omission errors
100	About 250 stimuli, or approx. 4.5 minutes	20%	Candy or cigarettes for correct responses	Omission errors
100	About 250 stimuli, or approx. 4.5 minutes	20%	Tokens for correct responses, variable ratio schedule	Omission errors
100	About 250 stimuli, or approx. 4.5 minutes	20%	Tokens for correct responses	Omission errors
50	18 minutes total	16.7%	None	Omission errors, Commission errors, Response latency
100	About 250 stimuli, or approx. 4.5 minutes	20%	Tokens for correct responses	Omission errors
NR	NR	NR	None	Omission errors, Commission errors
80	NR	20%	None	Omission errors, Commission errors

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
10. Cohler, Grunebaum, Weiss, Gamer, and Gallant 1977	26 mother-child pairs (schizophrenic), 14 mother-child pairs (psychotically depressed), 14 mother-child pairs (controls)	Revolving drum with viewing window	the color red for 5-year-olds, X for 6-year-olds	None	NR
11. Herman, Mirsky, Ricks, and Gallant 1977	6 high-risk Ss 6 control Ss	Carousel projector with rear projection screen	X	None	1000
12. Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1977	58 high-risk Ss 92 controls ("Sample A")	Carousel projector with rear projection screen	Identical pairs of playing cards	Auditory numbers	810
13. Spohn, Lacoursiere, Thompson, and Coyne 1977	40 initially unmedicated chronic schizophrenics	Lindsely Manipulum Board	X	None	1000
14. Asarnow and MacCrimmon 1978	20 acute schizophrenics, 20 remitted schizophrenics, 20 controls	Carousel projector with rear projection screen	7	Auditory digits	1200
15. Buchsbaum, Murphy, Coursey, Lake, and Zeigler 1978	37 Ss with low platelet MAO 32 Ss with high platelet MAO	Computer-controlled light emitting diode display	4-6	None	Dyna mic, subject driven ISI
16. Erlenmeyer-Kimling and Cornblatt 1978	80 high-risk Ss 100 controls ("Sample A")	Carousel projector with rear projection screen	Identical pairs of playing cards	Auditory digits	810
17. Grunebaum, Cohler, Kauffman, and Gallant 1978	18 mother-child pairs (schizophrenic), 12 mother-child pairs (psychotically depressed), 22 mother-child pairs (controls)	Revolving drum with viewing window	X	Auditory tones	NR

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
200	110 stimuli	NR	(received immediate feedback by way of a bell for correct responses)	Omission errors, Commission errors
200	330 stimuli, or about 9 minutes	30%	None	Hit rate, correct omissions
600	Two sessions of 323 stimuli, or about 8 minutes, each	12.5%	None	d' (perceptual sensitivity) and L_x (likelihood-ratio criterion)
100	About 250 stimuli, or approx. 4 minutes	20%	None	Omission errors
70	1120 stimuli, or 28 minutes	20%	None	Omission errors, Commission errors
NR	600 stimuli	10%	None	Omission errors, Commission errors, Mean ISI
600	Two sessions of 323 stimuli, or about 8 minutes, each	12.5%	None	Omission errors, Commission errors
200	NR	NR	None	Omission errors, Commission errors

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
18a. Kornetsky and Orzack 1978	19 medicated chronic schizophrenics	Lindsely Manipulum Board	X	None	1000
18b. Kornetsky and Orzack 1978	25 medicated chronic schizophrenics 8 control Ss	Lindsely Manipulum Board	X	None	1000
18c. Kornetsky and Orzack 1978		Lindsely Manipulum Board	X	None	1000
19. Buchsbaum and Sostek 1980	400 male students	Portable computer-controlled light emitting diode display	A-X	None	Dy-namic ISI, starts at 400 msec
20. Walker 1981	15 schizophrenics, 15 schizoaffectives 15 affective disorder Ss	NR	A-X	Unspecified auditory distraction	1200
21. Van den Bosch 1982	20 schizophrenics, 20 non-schizophrenic psychotics, 20 affective disorder Ss, 20 control Ss	Auditory presentation in a male voice	7-9 (simple version) 7 followed by 1 and 9 followed by 1 (complex version)	Auditory digits spoken in a female voice	1000
22. Walker and Green 1982	24 schizophrenics, 24 affective disorder Ss	Tachistoscopic presentation of stimuli	A-X	Auditory letters	1200
23. Walker and Shaye 1982	24 schizophrenics, 12 psychiatric controls, 12 normal controls	Tachistoscopic presentation of stimuli on rear-view projection screen	A-X	Auditory letters	1200

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
100	About 250 stimuli, or approx. 4.5 minutes	20%	NR	Omission errors
100	About 250 stimuli, or approx. 4.5 minutes	20%	NR	Omission errors
100	About 250 stimuli, or approx. 4.5 minutes	20%	NR	Omission errors
150	600 stimuli	10%	None	Omission errors, Commission errors, Mean ISI
150	80 trials	NR	None	Omission errors, Commission errors, Response latency
NR	500 stimuli, or about 8.5 minutes	20% (simple version) 10% (complex version)	None	Omission errors, Commission errors
150	80 trials	20%	None	Omission errors, Commission errors, Response latency
150	80 trials	NR	None	Omission errors, Commission errors, Response latency

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
24. Nuechterlein 1983	24 children of schizophrenics, 20 children of psychiatric control parents, 14 hyperactive children	Carousel projector with rear-view projection screen	Identical pairs of playing cards, The digit 5, Degraded version of the digit 0	None	1420
25. Nuechterlein, Parasuraman, and Jiang 1983	42 normal volunteers	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1000
26. Huhtaniemi, Haier, Fedio, and Buchsbaum 1983	13 male students in upper 5% of CPT performance, 12 in lower 5%	Portable computer-controlled light emitting diode display	4-6	None	Dy-namic ISI, starts at 400 msec
27. Cornblatt and Erlenmeyer-Kimling 1984	80 children of schizophrenics, 25 children of affective disorder parents, 100 control children ("Sample A"); 44 children of schizophrenics, 40 children of affective disorder parents, 66 control children ("Sample B")	Carousel projector with rear-view projection screen; also:	Identical pairs of playing cards (Sample A only)	Auditory numbers	810
		DEC VR14 oscilloscope, DEC PDP 11/10 computer and Sanyo video monitor	08 Identical pairs of the double digit 17	None	950
28. Buchsbaum, Haier, Sostek, Weingartner, Zahn, Siever, Murphy, and Brody 1984	400 college men	Portable computer-controlled light emitting diode display	A-X	None	Dy-namic ISI, starts at 400 msec

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
650 (playing cards) 40 or 50 (numeral conditions)	323 stimuli, or 7.6 minutes (playing cards) 243 stimuli, or 5.75 minutes (conventional numeral conditions) 486 stimuli, or 11.5 minutes (degraded versions of numeral CPT)	24.7% (all conditions)	(received immediate feedback for correct hits - - a bell -- and for false alarms -- an aversive buzzer)	d' β d' change over time (degraded CPT only)
40	486 stimuli, or just over 8 minutes	25%	None	A_z (perceptual sensitivity)
150	600 stimuli	10%	None	d'
600	640 stimuli, or about 15 minutes	12.5%	None	Hit rate, Commission errors, d'
50	600 stimuli, or about 10 minutes (08 version); 512 stimuli, or about 8.5 minutes (identical pairs double digit version)	20% (08 version) 24% (identical pairs double digit version)	Noncontingent social and monetary rewards between blocks of CPT trials	Correct response rate, Hit rate, False alarm rate, d' $\ln L_x$
150	600 stimuli	10%	None	d'

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
29. Erickson, Yellin, Hopwood, Realmuto, and Greenberg 1984	11 adolescent schizophrenics 11 attention deficit adolescents 21 conduct disordered adolescents 26 anxiety and eating disorder adolescents	Tachistoscopic presentation	White circle with a dot on the top	None	2000
30. Hamilton, Haier, and Buchsbaum 1984	48 college students	Portable computer-controlled light emitting diode display	A-X	None	Dynamic ISI, starts at 400 msec
31. Cornblatt and Erlenmeyer-Kimling 1985	63 children of schizophrenics, 43 children of affective disorder parents, 100 control children ("Sample A")	Carousel projector with rear-view projection screen	Identical pairs of playing cards	Auditory numbers	810
32a. Nuechterlein, Asarnow, and Marder 1985, in Nuechterlein 1985	50 low SES Ss	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1000
32b. Nuechterlein, Edell, and West 1985, in Nuechterlein 1985	16 college students with elevated 2-7-8 MMPI scores, 22 college students with other elevated MMPI scores, 24 college students with no elevated scores	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1000

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
100	NR	NR	None	Omission errors Commission errors Reaction time
150	600 stimuli	10%	None	Omission errors, Commission errors, Mean ISI
600	640 stimuli, or about 15 minutes	12.5%	None	Hit rate, Commission errors, d'
40	486 stimuli, or just over 8 minutes	25%	None	d'
40	486 stimuli, or just over 8 minutes	25%	None	d' hit rate

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
33. Berman, Zee, and Weinberger 1986	18 unmedicated schizophrenics, 17 control Ss	Computer monitor	X A-X	None	800 and dynamic
34. Nuechterlein, Edell, Norris and Dawson, 1986	40 schizophrenics	Carousel projector with rear-view projection screen	3-7 Degraded version of the digit 0	Auditory numbers (3-7 version only)	1000
35. Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1986	35 children of schizophrenics, 25 children of affective disorder parents, 53 control children ("Sample B")	DEC VR14 oscilloscope, DEC PDP 11/10 Sanyo video monitor	08 Identical pairs of the double digit 17	None	950
36. Strauss, Brandt, and McSorley 1986	30 paid volunteers	Carousel projector with rear-view projection screen	The digit 0, The digit 0 only if preceded by a 2 or 9 within three trials, Degraded version of the digit 0	None	1000
37. Wagener, Hogarty, Goldstein, Asarnow, and Browne 1986	25 schizophrenics and their mothers	Tachistoscopic presentation of stimuli	A-X	None	930
38. Cornblatt, Risch, Faris, Friedmand, and Erlenmeyer-Kimling 1988	59 normal parents 60 adolescent offspring	Tachistoscopic presentation using a portable Apple II Plus	Identical pairs of either 4-digit numbers or nonsense shapes	Randomly distributed asterisks on screen, or tape-recorded movie soundtrack	950
39. Böker, Brenner, and Würzler 1989	11 medicated chronic schizophrenics and 23 first-degree relatives	Tachistoscopic presentation with carousel projector	The digit 0	None	900

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
200	NR	20% (X version) NR (A-X version)	None	Omission errors Commission errors Mean response time
40	486 stimuli, or 8.1 minutes (degraded CPT) 684 stimuli, or 10.8 minutes (3-7 CPT)	24.6% (degraded CPT) 11.7% (3-7 CPT)	None	d' $\ln \beta$ d' change over time (degraded CPT only)
50	600 stimuli, or about 10 minutes (08 version) 512 stimuli, or about 8.5 minutes (identical pairs double digit version)	20% (08 version) 25% (identical pairs double digit version)	Noncontingent social and monetary rewards between blocks of CPT trials	Correct response rate, Hit rate, False alarm rate, d' $\ln L_x$
40	486 stimuli for each condition, or about 8 minutes per condition	25% (digit 0 and degraded 0 versions) 11% (memory load version)	None	A' (nonparametric signal detection index) change in A' over time
70	300 stimuli, or about 6 minutes	25%	None	Omission errors, Commission errors, Response latency
50	600 stimuli, or about 10 minutes	20%	None	d' $\ln \beta$
100	250 stimuli, or just over 4 minutes	20%	None	Omission errors

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
40. Cornblatt, Lenzenweger, and Erlenmeyer-Kimling 1989	14 schizophrenics, 17 depressed Ss, 28 controls	Tachistoscopic presentation using a portable Apple II Plus	Identical pairs of either 4-digit numbers or nonsense shapes	Randomly distributed asterisks on screen, or overlapping numerals, or tape-recorded movie soundtrack	950
41. Guich, Buchsbaum, Burgwald, Wu, Haier, Asarnow, Nuechterlein, and Potkin 1989	15 schizophrenics, 9 volunteers	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1960
42. Nuechterlein, Goldstein, Ventura, Dawson, and Doane 1989	40 recent onset schizophrenics	Carousel projector with rear-view projection screen	3-7 Degraded version of the digit 0	None	1000
43. Wagner, Kurtz, and Engel 1989	14 schizophrenics, 14 controls	Projection of stimuli on screen	P	None	1500 (invariant cond.) 1500-3000 (variable cond.)
44. Buchsbaum, Nuechterlein, Haier, Wu, Sicotte, Hazlett, Asarnow, Potkin, and Guich 1990	13 schizophrenics, 37 volunteers	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1960
45. Harvey, Keefe, Moskowitz, Putnam, Mohs, and Davis 1990	14 medicated schizophrenics, 14 unmedicated schizophrenics, 15 control Ss	Taxan monitor with IBM AT compatible computer	3-7	None	1000
46. Mussgay and Hertwig 1990	24 male schizophrenics, 24 control Ss	Hewlett Packard 1300 X-Y display and microcomputer	0 (either upper or lower case)	None	1332

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
50	600 stimuli, or about 10 minutes	20%	None	d' $\ln \beta$
40	20-40 minutes	25%	None	d'
40	486 stimuli, or 8.1 minutes (degraded CPT) 684 stimuli, or 10.8 minutes (3-7 CPT)	24.6% (degraded CPT) 11.7% (3-7 CPT)	None	d' $\ln \beta$ d' change over time (degraded CPT only)
50	625 stimuli	20%	None	Omission errors Commission errors Reaction time
40	32 to 37 minutes	25%	None	d'
50	500 stimuli, or about 8.5 minutes	10%	None	Omission errors Commission errors Reaction time to correct detections d'
195	168 trials, or 5 minutes	33%	None	A' change in A' over time B''

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
47. Nestor, Faux, McCarley, Shenton, and Sands 1990	22 male schizophrenics, 21 control Ss	Amdek color 710 monitor and micro-computer	Degraded version of the digit 0	None	Varied from 1100 to 1300
48. Serper, Bergman, and Harvey 1990	4 medicated schizophrenics 4 unmedicated schizophrenics 4 control Ss	Tachistoscopic presentation using an IBM PC	3-7	(Protocol involved a secondary task of shadowing words outloud)	1000
49. Earle-Boyer, Serper, Davidson, and Harvey 1991	17 medicated schizophrenics 17 unmedicated schizophrenics 19 control Ss	NR	3-letter words: "day" followed by "far" or "sit" followed by "pay"; 3-letter nonsense syllables: "gok" followed by "sij" or "cug" followed by "dof"	None	1000
50. Grove, Lebow, Clementz, Cerri, Medus, and Iacono 1991	17 schizophrenics, 61 first-degree relations, 18 control Ss	Taxan multivision 770 CRT, IBM XT microcomputer	Degraded version of the digit 8	None	960
51. Lenzenweger, Cornblatt, and Putnick 1991	32 schizotypic Ss 43 control Ss	Tachistoscopic presentation using a portable Apple IIe	Identical pairs of either 4-digit numbers or nonsense shapes	Randomly distributed asterisks on screen, or tape-recorded nonsense sounds, or tape-recorded lectures	950
52. Nestor, Faux, McCarley, Shenton, and Sands 1991	22 male schizophrenics, 22 control Ss	Amdek color 710 monitor and microcomputer	Degraded version of the digit 0	None	Varied from 1100 to 1300
53. Steinhauer, Zubin, Condray, Shaw, Peters, and van Kammen 1991	30 schizophrenics 23 brothers of schizophrenics 19 male controls	NR	Degrade stimuli	None	NR

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
100	486 stimuli, or 10.5 minutes	25%	None	A' change in A' over time B"
50	500 stimuli, or about 1 hour and 25 minutes, repeated over 16 days	10%	None	Omission errors, Commission errors
500	60 stimuli for 3-letter word and 60 stimuli for 3-letter nonsense syllable conditions	20%	None	Omission errors, Commission errors
40	4 blocks of 360 trials each	25%	None	d'
50	150 stimuli under each of 8 conditions, or a total of about 20 minutes	19%	None	d' $\ln \beta$
100	486 stimuli, or 10.5 minutes	25%	None	A' change in A' over time B"
NR	NR	NR	None	d' β

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
54. Winters, Cornblatt, and Erlenmeyer-Kimling 1991	("Sample B")	Tachistoscopic presentation using a portable Apple II Plus	Identical pairs of either 4-digit numbers or nonsense shapes	Randomly distributed asterisks on screen, or overlapping numerals, or tape-recorded movie soundtrack	950
55. Condray and Steinhauer 1992	10 schizotypal Ss with schizophrenic relatives 15 schizotypal Ss without schizophrenic relatives	Carousel with rear-projection view screen	Degraded version of the digit 0	None	1000
56. Corrigan, Wallace, and Green 1992	30 schizophrenics, 15 control Ss	Tachistoscopic presentation using an IBM PC with a Taxan 720 color monitor	Degraded version of the digit 0	None	940
57. Obiols, Clos, Corberó, García-Domingo, de Trinchería, and Doménech 1992	39 schizophrenics, 35 schizotypics, 33 control Ss	IBM PC	Identical pairs of either 4-digit numbers or nonsense shapes	Randomly distributed shapes or 4-digit numbers	950
58. Erlenmeyer-Kimling, Cornblatt, Rock, Roberts, Bell, and West 1993	43 offspring of schizophrenics, 32 offspring of affective disorder parents, 86 control offspring ("Sample A")	Carousel projector with rear projection screen	Identical pairs of playing cards	Auditory digits	810
59. Hain, Maier, Klinger, and Franke 1993	49 unmedicated schizophrenics, 27 control Ss	NR	Degraded version of the digit 0	None	960 or 930
60. Hazlett, Dawson, Buchsbaum, and Nuechterlein 1993	6 unmedicated schizophrenics, 6 control Ss	Carousel projector with rear-view projection screen	Degraded version of the digit 0	None	1960

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
50	600 stimuli, or about 10 minutes	20%	None	d' In β
50	486 stimuli, or about 8.5 minutes	25%	None	Hit rate Commission errors d'
60	480 stimuli, or about 8 minutes	25%	None	A' change in A' over time
50	600 stimuli	20%	None	d'
600	Two sessions of 323 stimuli, or about 8 minutes, each	12.5%	None	Omission errors, Commission errors
40 or 70	480 stimuli or about 8 minutes in each condition	25%	None	d' β
40	32 to 37 minutes	25%	None	d'

Study	N	Apparatus	Target Stimuli	Distraction	ISI* (msec)
61. Benedict, Harris, Markow, McCormick, Nuechterlein, and Asarnow 1994	38 schizophrenics	IBM compatible portable computer, Taxan 620 monitor and Gravis MK-VI analogue controller joystick	Degraded version of the digit 0	None	930
62. Bowen, Wallace, Glynn, Nuechterlein, Lutzker, and Kuehnel 1994	30 schizophrenics, 15 control Ss	IBM microcomputer	Conventional 0, degraded version of the digit 0	None	940
53. Wilson and Costanzo 1995	57 college students	Apple II microcomputer screen	H-T	None	Dyna mic ISI, starts at 500 msec

* ISI = Interstimulus interval

** NR = not reported

***Reported in more detail in Asarnow, Steffy MacCrimmon, and Cleghorn 1978

Note: Space does not permit inclusion of a number of important follow-up reports from Erlenmeyer-Kimling and Cornblatt's New York High-Risk Study, or from Garnezy's Minnesota High-Risk Studies, in which Nuechterlein participated as a principal investigator. In these reports, secondary analyses were conducted on previously reported CPT scores, or in which previously published findings have been collected together and summarized. See, e.g., Cornblatt and Marcuse 1986; Cornblatt, Lenzenweger, Dworkin and Erlenmeyer-Kimling 1992; Cornblatt, Winters, and Erlenmeyer-Kimling 1989; Erlenmeyer-Kimling and Cornblatt 1992; Erlenmeyer-Kimling et al. 1982; Erlenmeyer-Kimling, Cornblatt, and Golden 1983; and Erlenmeyer-Kimling, Golde., and Cornblatt 1989; Nuechterlein 1984b; Nuechterlein, Garnezy, and Devine 1989; Nuechterlein, Phipps-Yonas, Driscoll, and Garnezy 1990.

Stimulus Duration (msec)	Task Duration	Percentage of Target Stimuli in Sequence	Reinforcement	Outcome Measures
70	460 trials, or about 8 minutes	25%	None	A'
60	480 trials, or about 8 minutes	25%	None	A' Change in A' with time B''
120	8 to 10 minutes	10%	None	Hit rate False alarm rate d' $\ln \beta$

APPENDIX B

Relationships and Experiences Questionnaire
for Students

1. For the first question, please indicate which of the following best describes your feelings. Please indicate only ONE description by circling the single appropriate circle letter.

A.	I find it relatively easy to get close to others and am comfortable depending on them and having them depend on me. I don't often worry about being abandoned or about someone getting too close to me.
B.	I am somewhat uncomfortable being close to others; I find it difficult to trust them completely, difficult to allow myself to depend on them. I am nervous when anyone gets too close, and often, people want me to be more intimate than I feel comfortable being.
C.	I find that others are reluctant to get as close as I would like. I often worry that my partner or close friend doesn't really love me or won't want to stay with me. I want to merge completely with another person, and this desire sometimes scares people away.

Questions 2 - 46 are a set of statements about relationships and experiences that some people may consider personally descriptive. There are no right or wrong answers. Please indicate how you feel about each statement by circling the ONE number that tells how characteristic the statement is for you. Please be sure to respond to every statement.

	Not at All Character- istic	Slightly Character- istic	Somewhat Character- istic	Fairly Character- istic	Very Character- istic
2. I find it relatively easy to get close to people.	1	2	3	4	5
3. I find it difficult to allow myself to depend on others.	1	2	3	4	5
4. In relationships, I often worry that my partner does not really love me.	1	2	3	4	5
5. I find that others are reluctant to get as close as I would like.	1	2	3	4	5

		Not at All Character- istic	Slightly Character- istic	Somewhat Character- istic	Fairly Character- istic	Very Character- istic
6.	I am comfortable depending on others.	1	2	3	4	5
7.	I do <u>not</u> worry about someone getting too close to me.	1	2	3	4	5
8.	I find that people are never there when you need them.	1	2	3	4	5
9.	I am <u>un</u> comfortable being close to people.	1	2	3	4	5
10.	In relationships, I often worry that my partner will not want to stay with me.	1	2	3	4	5
11.	When I show my feelings for people, I'm afraid they will not feel the same about me.	1	2	3	4	5
12.	In relationships, I often wonder whether my partner really cares about me.	1	2	3	4	5
13.	I am comfortable developing close relationships with others.	1	2	3	4	5
14.	I am nervous when anyone gets too close to me.	1	2	3	4	5
15.	I know that people will be there when I need them.	1	2	3	4	5
16.	I want to get close to people but I worry about being hurt by them.	1	2	3	4	5
17.	I find it difficult to trust others completely.	1	2	3	4	5
18.	Often, people want me to be closer than I feel comfortable being.	1	2	3	4	5
19.	I am not sure that I can always depend on people to be there when I need them.	1	2	3	4	5

		Not at All Character- istic	Slightly Character- istic	Somewhat Character- istic	Fairly Character- istic	Very Character- istic
20.	I am not easily confused if a number of things happen at the same time.	1	2	3	4	5
21.	When I pass flowers I often stop to smell them.	1	2	3	4	5
22.	I attach little importance to having close friends.	1	2	3	4	5
23.	I often change between positive and negative feelings towards the same person.	1	2	3	4	5
24.	Writing letters to friends is more trouble than it's worth.	1	2	3	4	5
25.	I often get a restless feeling that I want something but do not know what.	1	2	3	4	5
26.	When I have been extremely happy I have sometimes felt like hugging someone.	1	2	3	4	5
27.	I suddenly feel shy when I want to talk to a stranger.	1	2	3	4	5
28.	Beautiful scenery has been a great delight to me.	1	2	3	4	5
29.	Getting together with old friends has been one of my greatest pleasures.	1	2	3	4	5
30.	I am not usually self-conscious.	1	2	3	4	5
31.	I find it difficult to concentrate; irrelevant things seem to distract me.	1	2	3	4	5
32.	When introduced to strangers I often wonder whether I have known them before.	1	2	3	4	5
33.	Now and then when I look in the mirror, my face seems quite different from usual.	1	2	3	4	5

		Not at All Character- istic	Slightly Character- istic	Somewhat Character- istic	Fairly Character- istic	Very Character- istic
34.	People can easily influence me even though I thought my mind was made up on a subject.	1	2	3	4	5
35.	A brisk walk has sometimes made me feel good all over.	1	2	3	4	5
36.	I often have grave difficulties in controlling my thoughts when I am thinking.	1	2	3	4	5
37.	When anticipating a visit from a friend I have often felt happy and excited.	1	2	3	4	5
38.	I have been fascinated with the dancing of flames in a fireplace.	1	2	3	4	5
39.	The idea of going out and mixing with people at parties has always pleased me.	1	2	3	4	5
40.	I prefer others to make decisions for me.	1	2	3	4	5
41.	Sometimes people whom I know well begin to look like strangers.	1	2	3	4	5
42.	I have thoroughly enjoyed laughing at jokes with other people.	1	2	3	4	5
43.	Good luck charms do not work.	1	2	3	4	5
44.	I get a lot of pleasure from listening to music.	1	2	3	4	5
45.	I have sometimes felt that strangers were reading my mind.	1	2	3	4	5
46.	I do not understand why people enjoy looking at the stars at night.	1	2	3	4	5

The following set of questions ask about your childhood relationships. Please read each of the following statements and indicate the ONE number that tells how strongly you agree or disagree that each statement describes your childhood relationship with the people indicated.

	When I was a child, my <u>mother</u> (or mother substitute) . . .	Strongly Disagree with Statement	Somewhat Disagree with Statement	Uncertain about Statement	Somewhat Agree with Statement	Strongly Agree with Statement
47.	encouraged me to make my own decisions.	1	2	3	4	5
48.	helped me learn to be independent	1	2	3	4	5
49.	felt she had to fight my battles for me when I had a disagreement with a teacher or a friend.	1	2	3	4	5
50.	was close to a perfect parent.	1	2	3	4	5
51.	was over protective of me.	1	2	3	4	5
52.	encouraged me to do things for myself.	1	2	3	4	5
53.	encouraged me to try things my way.	1	2	3	4	5
54.	had not a single fault I can think of.	1	2	3	4	5
55.	did not let me do things that other kids my age were allowed to do.	1	2	3	4	5
56.	sometimes disapproved of specific things I did, but never gave me the impression that she disliked me as a person.	1	2	3	4	5
57.	enjoyed being with me.	1	2	3	4	5
58.	was an ideal person in every way.	1	2	3	4	5
59.	was someone I found very difficult to please	1	2	3	4	5
60.	usually supported me when I wanted to do new and exciting things.	1	2	3	4	5
61.	worried too much that I would hurt myself or get sick.	1	2	3	4	5
62.	was never angry with me.	1	2	3	4	5

	When I was a child, my <u>mother</u> (or mother substitute) . . .	Strongly Disagree with Statement	Somewhat Disagree with Statement	Uncertain about Statement	Somewhat Agree with Statement	Strongly Agree with Statement
63.	was often rude to me.	1	2	3	4	5
64.	rarely did things with me.	1	2	3	4	5
65.	didn't like to have me around the house.	1	2	3	4	5
66.	and I never disagreed.	1	2	3	4	5
67.	would often do things for me that I could do for myself.	1	2	3	4	5
68.	let me handle my own money.	1	2	3	4	5
69.	could always be depended upon when I really needed her help and trust.	1	2	3	4	5
70.	gave me the best upbringing anyone could ever have.	1	2	3	4	5
71.	did not want me to grow up.	1	2	3	4	5
72.	tried to make me feel better when I was unhappy.	1	2	3	4	5
73.	encouraged me to express my own opinion.	1	2	3	4	5
74.	never disappointed me.	1	2	3	4	5
75.	made me feel that I was a burden to her.	1	2	3	4	5
76.	gave me the feeling that she liked me as I was; she didn't feel she had to make me over into someone else.	1	2	3	4	5

When I was a child, my father
(or father substitute) . . .

77.	encouraged me to make my own decisions.	1	2	3	4	5
78.	helped me learn to be independent	1	2	3	4	5
79.	felt he had to fight my battles for me when I had a disagreement with a teacher or a friend.	1	2	3	4	5

	When I was a child, my <u>father</u> (or father substitute) . . .	Strongly Disagree with Statement	Somewhat Disagree with Statement	Uncertain about Statement	Somewhat Agree with Statement	Strongly Agree with Statement
80.	was close to a perfect parent.	1	2	3	4	5
81.	was overprotective of me.	1	2	3	4	5
82.	encouraged me to do things for myself.	1	2	3	4	5
83.	encouraged me to try things my way.	1	2	3	4	5
84.	had not a single fault I can think of.	1	2	3	4	5
85.	did not let me do things that other kids my age were allowed to do.	1	2	3	4	5
86.	sometimes disapproved of specific things I did, but never gave me the impression that he disliked me as a person.	1	2	3	4	5
87.	enjoyed being with me.	1	2	3	4	5
88.	was an ideal person in every way.	1	2	3	4	5
89.	was someone I found very difficult to please	1	2	3	4	5
90.	usually supported me when I wanted to do new and exciting things.	1	2	3	4	5
91.	worried too much that I would hurt myself or get sick.	1	2	3	4	5
92.	was never angry with me.	1	2	3	4	5
93.	was often rude to me.	1	2	3	4	5
94.	rarely did things with me.	1	2	3	4	5
95.	didn't like to have me around the house.	1	2	3	4	5
96.	and I never disagreed.	1	2	3	4	5

	When I was a child, my <u>father</u> (or father substitute) . . .	Strongly Disagree with Statement	Somewhat Disagree with Statement	Uncertain about Statement	Somewhat Agree with Statement	Strongly Agree with Statement
97.	would often do things for me that I could do for myself.	1	2	3	4	5
98.	let me handle my own money.	1	2	3	4	5
99.	could always be depended upon when I really needed his help and trust.	1	2	3	4	5
100.	gave me the best upbringing anyone could ever have.	1	2	3	4	5
101.	did not want me to grow up.	1	2	3	4	5
102.	tried to make me feel better when I was unhappy.	1	2	3	4	5
103.	encouraged me to express my own opinion.	1	2	3	4	5
104.	never disappointed me.	1	2	3	4	5
105.	made me feel that I was a burden to him.	1	2	3	4	5
106.	gave me the feeling that he liked me as I was; he didn't feel he had to make me over into someone else.	1	2	3	4	5

When I was a child, other
children . . .

107.	liked to play with me	1	2	3	4	5
108.	were always criticizing me.	1	2	3	4	5
109.	often shared things with me.	1	2	3	4	5
110.	often picked on me and teased me.	1	2	3	4	5
111.	were usually friendly with me.	1	2	3	4	5
112.	would usually stick up for me.	1	2	3	4	5
113.	liked to ask me to go along with them.	1	2	3	4	5

	When I was a child, <u>other children</u> . . .	Strongly Disagree with Statement	Somewhat Disagree with Statement	Uncertain about Statement	Somewhat Agree with Statement	Strongly Agree with Statement
114	wouldn't listen when I tried to say something	1	2	3	4	5
115	were often unfair to me.	1	2	3	4	5
116	would often try to hurt my feelings.	1	2	3	4	5

In this final section of the questionnaire, you will be presented with a series of vignettes. Each one describes a hypothetical incident and lists three ways of responding to it. Please read each vignette and consider how likely it is that you would respond in that way. Then rate each response option in terms of how likely it is that you would respond in that way. We all respond in a variety of ways to situations, and probably each response is at least slightly likely for you. You should rate each of three responses for each vignette.

		Not at All Likely	Slightly Likely	Somewhat Likely	Fairly Likely	Very Likely
Vignette: You have been offered a new position in a company where you have worked for some time. The first question that is likely to come to mind is:						
117	What if I can't live up to the new responsibility?	1	2	3	4	5
118	Will I make more at this position?	1	2	3	4	5
119	I wonder if the new work will be interesting?	1	2	3	4	5
Vignette: You have a school age daughter. On parents' night the teacher tells you that your daughter is doing poorly and doesn't seem involved in the work. You are likely to:						
120	Talk it over with your daughter to understand further what the problem is.	1	2	3	4	5
121	Scold her and hope she does better.	1	2	3	4	5
122	Make sure she does the assignments, because she should be working harder.	1	2	3	4	5

		Not at All Likely	Slightly Likely	Somewhat Likely	Fairly Likely	Very Likely
Vignette: You had a job interview several weeks ago. In the mail you received a form letter which states that the position has been filled. It's likely that you might think:						
123	It's not what you know, but who you know.	1	2	3	4	5
124	I'm probably not good enough for the job.	1	2	3	4	5
125	Somehow that didn't see my qualifications as matching their needs.	1	2	3	4	5
Vignette: You are a plant supervisor and have been charged with the task of allotting coffee breaks to three workers who can not all take breaks at the same time. You would likely handle this by:						
126	Telling the three workers the situation and having them work with you on the schedule.	1	2	3	4	5
127	Simply assign the times that each can break to avoid any problems.	1	2	3	4	5
128	Find out from someone in authority what to do or do what was done in the past.	1	2	3	4	5
Vignette: A close friend of yours has been moody lately, and a couple of times has become very angry with you over "nothing." You might:						
129	Share your observations with him and try to find out what is going on for him.	1	2	3	4	5
130	Ignore it because there's not much you can do about it anyway.	1	2	3	4	5
131	Tell him that you're willing to spend time together if and only if he makes more effort to control himself.	1	2	3	4	5

		Not at All Likely	Slightly Likely	Somewhat Likely	Fairly Likely	Very Likely
Vignette: You have just received the results of a test you took, and you discovered that you did very poorly. Your initial reaction is likely to be:						
132	"I can't do anything right," and feel sad.	1	2	3	4	5
133	"I wonder how it is I did so poorly," and feel disappointed.	1	2	3	4	5
134	"That stupid test doesn't show anything," and feel angry.	1	2	3	4	5
Vignette: You have been invited to a large party where you know very few people. As you look forward to the evening you would likely expect that:						
135	You'll try to fit in with whatever is happening in order to have a good time and not look bad.	1	2	3	4	5
136	You'll find some people with whom you can relate.	1	2	3	4	5
137	You'll probably feel somewhat isolated and unnoticed.	1	2	3	4	5
Vignette: You are asked to plan a picnic for yourself and your fellow employees. Your style for approaching this project could most likely be characterized as:						
138	Take charge: that is, you would make most of the major decisions yourself.	1	2	3	4	5
139	Follow precedent: you're not really up to the task so you'd do it the way it's been done before.	1	2	3	4	5
140	Seek participation: get inputs from others who want to make them before you make the final plans.	1	2	3	4	5

		Not at All Likely	Slightly Likely	Somewhat Likely	Fairly Likely	Very Likely
Vignette: Recently a position opened up at your place of work that could have meant a promotion for you. However, a person you work with was offered the job rather than you. In evaluating the situation, you are likely to think:						
141	You didn't really expect the job: you frequently get passed over.	1	2	3	4	5
142	The other person probably "did the right things" politically to get the job.	1	2	3	4	5
143	You would probably take a look at factors in your own performance that lead to your being passed over.	1	2	3	4	5
Vignette: You are embarking on a new career. The most important consideration is likely to be:						
144	Whether you can do the work without getting in over your head.	1	2	3	4	5
145	How interested you are in that kind of work.	1	2	3	4	5
146	Whether there are good possibilities for advancement.	1	2	3	4	5
Vignette: A man who works for you has generally done an adequate job. However, for the past two weeks his work has not been up to par and he appears to be less actively interested in his work. Your reaction is likely to be:						
147	Tell him that his work is below what is expected and that he should start working harder.	1	2	3	4	5
148	Ask him about the problem and let him know you are available to help work it out.	1	2	3	4	5
149	It's hard to know what to do to get him straightened out.	1	2	3	4	5

		Not at All Likely	Slightly Likely	Somewhat Likely	Fairly Likely	Very Likely
Vignette: Your company has promoted you to a position in a city far from your present location. As you think about the move you would probably:						
150	Feel interested in the new challenge and a little nervous at the same time.	1	2	3	4	5
151	Feel excited about the higher status and salary that is involved..	1	2	3	4	5
152	Feel stressed and anxious about the upcoming changes.	1	2	3	4	5

This completes the questionnaire. Thank you so much for your time and patience!

APPENDIX C

Intrinsic Motivation Inventory

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
I did not feel nervous at all while doing this activity.	1	2	3	4	5	6	7
This activity did not hold my attention at all.	1	2	3	4	5	6	7
I felt like I had to do this.	1	2	3	4	5	6	7
I was pretty skilled at this task.	1	2	3	4	5	6	7
I tried very hard to do well at this activity.	1	2	3	4	5	6	7
I am satisfied with my performance at this task.	1	2	3	4	5	6	7
I was very relaxed in doing this activity.	1	2	3	4	5	6	7
I felt like it was not my own choice to do this task.	1	2	3	4	5	6	7
I didn't put much energy into this.	1	2	3	4	5	6	7
I enjoyed this task very much.	1	2	3	4	5	6	7
It was important to me to do well at this task.	1	2	3	4	5	6	7
After working at this activity for a while, I felt pretty competent.	1	2	3	4	5	6	7
I felt pressured while doing this task.	1	2	3	4	5	6	7
I did this activity because I wanted to.	1	2	3	4	5	6	7
I believe I had some choice about doing this activity.	1	2	3	4	5	6	7

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
I thought this activity was quite enjoyable.	1	2	3	4	5	6	7
I thought this was a boring activity.	1	2	3	4	5	6	7
This was an activity that I couldn't do very well.	1	2	3	4	5	6	7
I did this activity because I had to.	1	2	3	4	5	6	7
I didn't try very hard to do well at this activity.	1	2	3	4	5	6	7
I felt very tense while doing this activity.	1	2	3	4	5	6	7
I would describe this activity as very interesting.	1	2	3	4	5	6	7
I think I did pretty well at this activity, compared to other students.	1	2	3	4	5	6	7

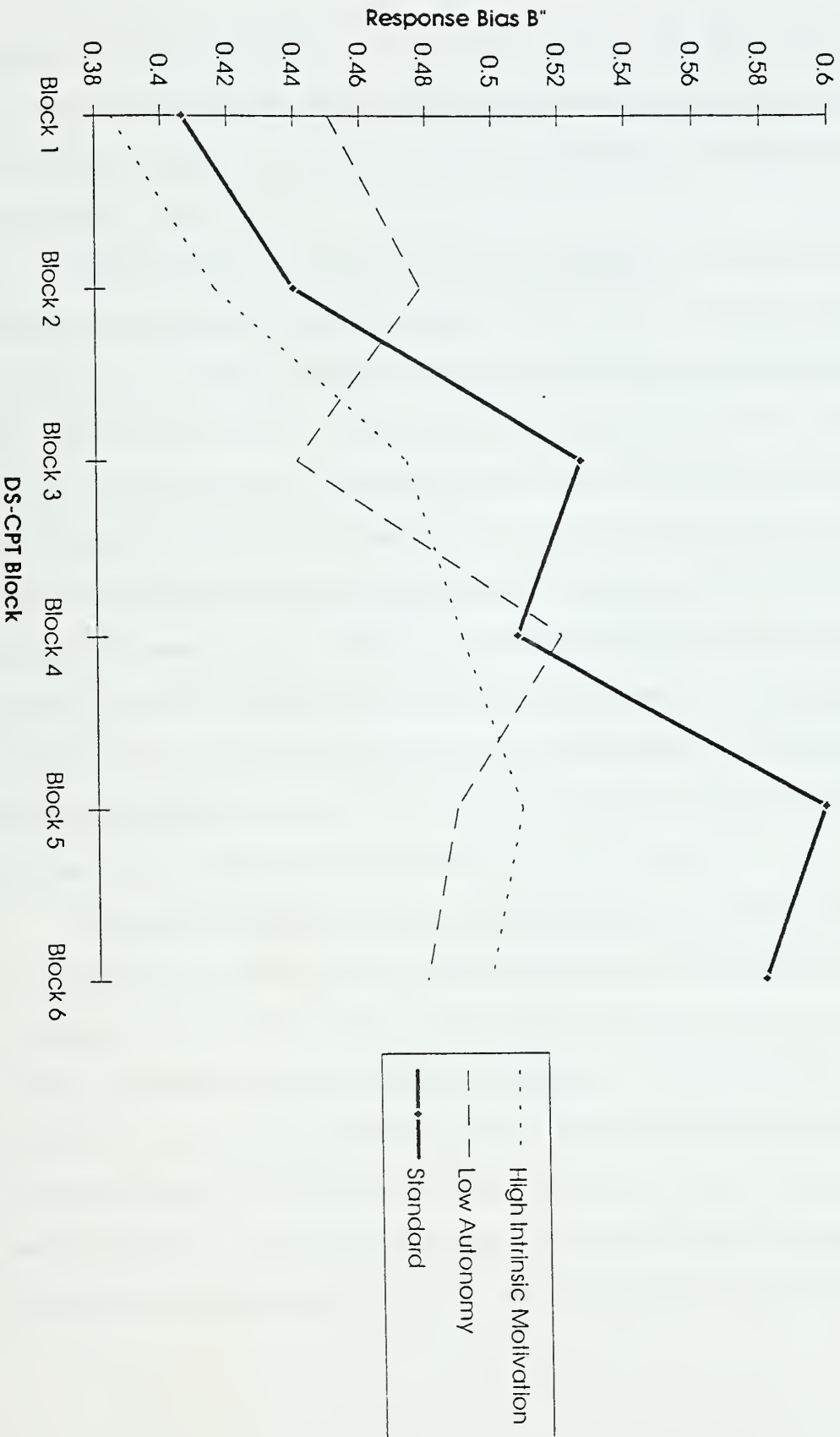
APPENDIX D

Growth Curve Analyses Predicting Response Bias B"

Because response bias is thought to reflect multiple and diffuse factors that affect individuals' strategies for responding to stimuli in vigilance tasks, it has generally not been a focus of schizophrenia research with the CPT. Instead, this research has focused on perceptual sensitivity as an index of the neurointegrative deficit thought to characterize subsamples of schizophrenia spectrum disorders. To the extent that schizophrenia researchers have investigated response bias, they have found schizophrenics' and control participants' scores not to differ. This finding was replicated here, as was the independence of response bias from perceptual sensitivity. Nevertheless, the impact that motivation and other variables of interest might have on response bias constitutes a separate set of valid research questions, and significant findings are reported here for that reason.

Effect of schizotypy and motivational induction on DS-CPT response bias. For response bias, only the main effect for condition on the slope was significant ($F(3, 1142) = 11.85, p < .0001$). Neither schizophrenia nor anhedonia influenced initial levels of response bias or their increase with time. The effect for motivational condition on the initial level of response bias was nonsignificant. The effect for motivation condition on the rate of increase in response bias is shown in Figure D1. As indicated there, the slope for response bias in the low autonomy condition was essentially flat ($\beta = .0158, t(1142) = 1.46, ns$), the slope was greatest for the standard DS-CPT induction ($\beta = .0370, t(1142) = 5.23, p < .0001$), and it was intermediate for the intrinsic motivation condition ($\beta = .0223, t(1142) = 3.11, p < .0019$). Follow-up pairwise contrasts indicated that only the difference in slopes for the standard induction and the low autonomy condition was significant ($F(1, 1142) = 7.48, p < .0064$). Post hoc comparisons indicated that this difference resulted in marginally significant differences in response bias for the two conditions by the fifth and sixth blocks ($F(2, 188) = 3.53, p < .0617$, and $F(2, 188) =$

Figure D1. The Effect of Motivational Inductions on Response Bias



2.67, $p < .1042$, respectively). As was the case in predicting perceptual sensitivity, the motivational inductions, despite their highly significant effects on the slope, did not result in significant differences in the summary score for response bias averaged across the six blocks, $F(2, 188) = .92$, ns.

Effect of intrinsic motivation on DS-CPT performance. For response bias, global intrinsic motivation had a marginally significant effect on the intercept ($F(1, 1092) = 3.58$, $p < .0588$) and a significant effect on the slope after controlling for the effect of motivational induction ($F(1, 1092) = 5.09$, $p < .0243$). Intrinsic motivation did not interact with schizophrenia, anhedonia or motivational condition to predict the two growth curve parameters for response bias. Main effects for intrinsic motivation are illustrated in Figure D2; again, participants are split into high and low intrinsic motivation groups at the mean. Figure D2 reveals that participants who reported high intrinsic motivation were both initially and consistently more conservative in responding than were participants who reported low intrinsic motivation. Surprisingly, these effects did not result in a significant relationship between intrinsic motivation and the summary score for response bias averaged over the six blocks ($F(1, 181) = .03$, ns).

Relationship of effort as assessed by the dynamometer task to DS-CPT performance. For response bias, persistence had no effect on the intercept but significantly predicted slope after controlling for the effect of motivational induction ($F(1, 1141) = 4.30$, $p < .0384$). Interactions with schizophrenia, anhedonia and motivational induction were not significant. The main effect of persistence on the rate of increase in response bias is illustrated in Figure D3, again with participants divided at the mean into high and low persistence groups. Like participants reporting high levels of intrinsic motivation, participants who persisted longer at the dynamometer task generally grew more conservative

Figure D2. The Effect of High and Low Intrinsic Motivation on Response Bias

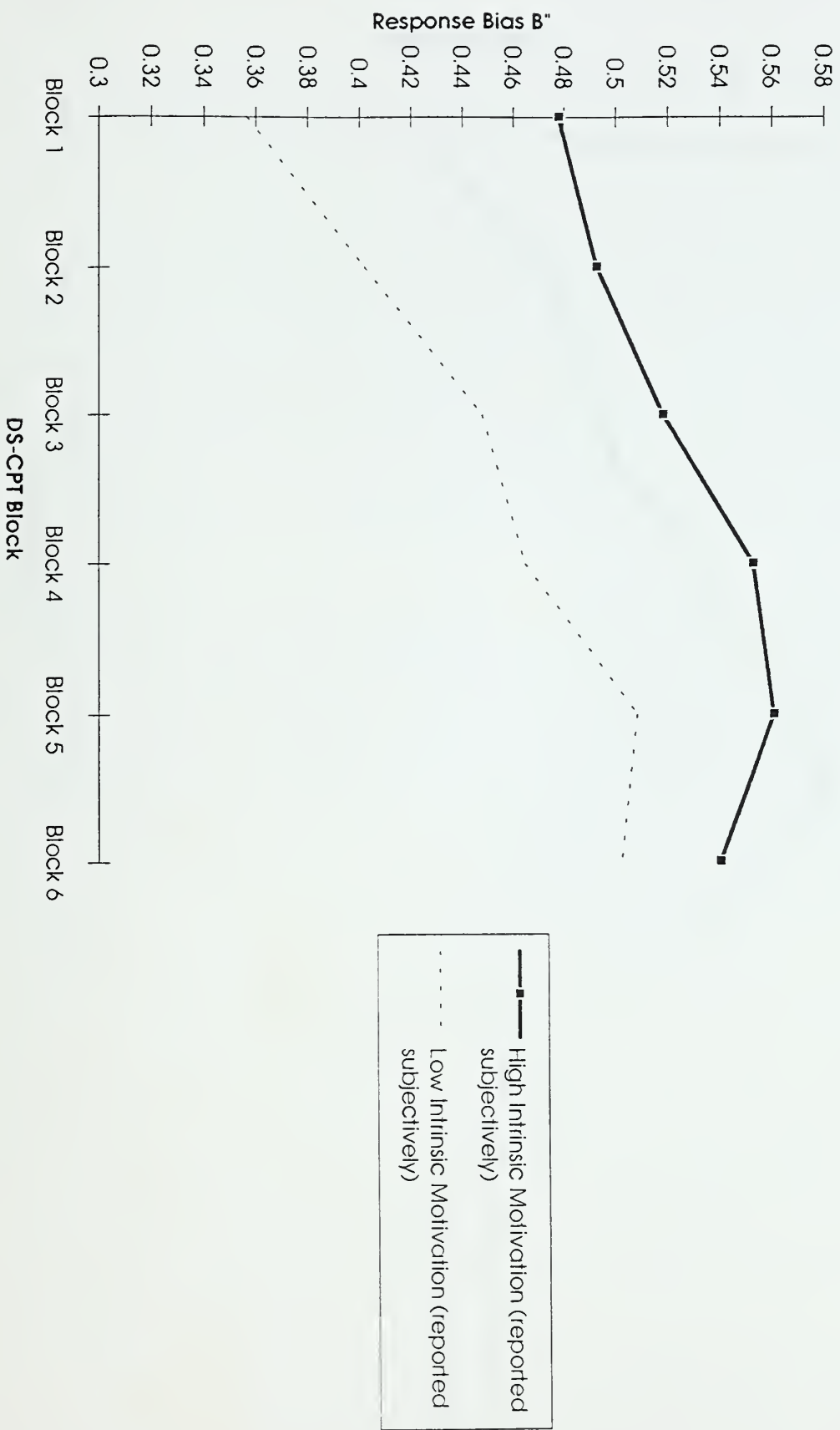
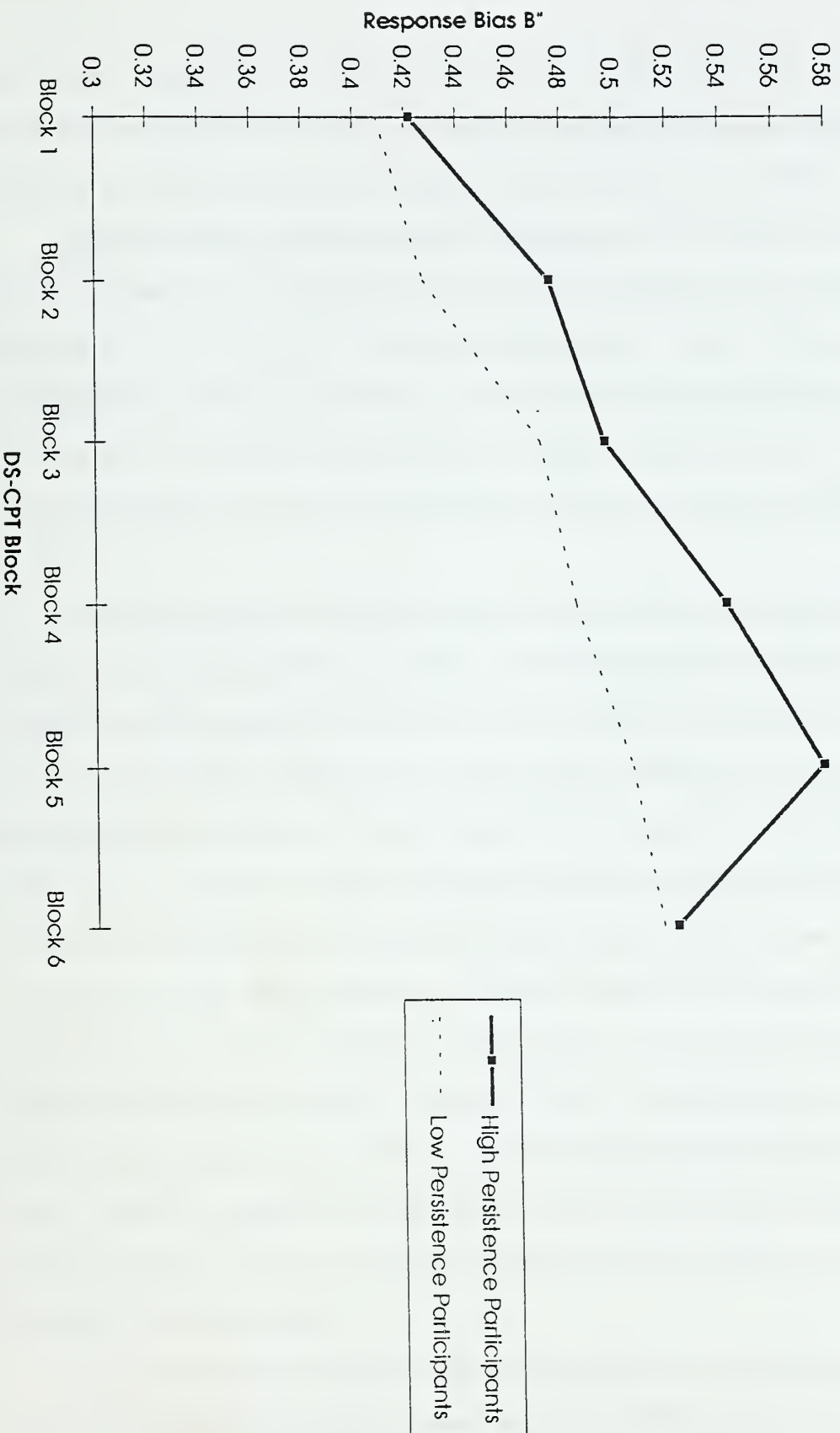


Figure D3. Relationship between Persistence and Response Bias



than those who persisted for shorter periods. Also like the findings for intrinsic motivation, this effect did not result in a significant relationship between persistence and the summary scores for response bias averaged over the six blocks ($F(1, 189) = 2.73$, ns).

Effect of positive emotion on DS-CPT performance. For response bias, the interactions between global emotionality and motivational condition predicted both the intercept ($F(2, 1128) = 3.17$, $p < .0425$) and the slope ($F(2, 1128) = 3.23$, $p < .0397$) after controlling for all lower order effects. Global positive emotion did not interact with schizophrenia or anhedonia to predict either of the growth curve parameters. The significant interactions with motivational induction condition are displayed in Figures D4a-c.

Follow-up analyses within motivational induction condition indicated the following results. First, in the high intrinsic motivation condition (Figure D4a), there was a trend for increases in positive emotion to be associated with decreases in initial levels of response bias ($F(1, 251) = 2.81$, $p < .095$), but no effect of positive emotion on the rate of increase in response bias ($F(1, 251) = .41$, ns). Second, in the low autonomy condition (Figure D4b), there was a trend for increases in positive emotion to be associated with increases in initial levels of response bias ($F(1, 248) = 3.00$, $p < .085$), an effect that was opposite from that found in the intrinsic motivation condition. Also in the low autonomy condition, increases in positive emotion resulted in a smaller slope -- that is, in smaller increases in response bias with time ($F(1, 248) = 5.75$, $p < .0172$). This effect may have resulted from the initially higher level of response bias at which high positive emotion participants started. Third, in the standard induction condition (Figure D4c), positive emotion was unrelated to either the intercept or the slope of response bias ($F(1, 260) = .01$, ns, and $F(1, 260) = .79$, ns, respectively).

Thus it appears that emotion may be an important factor to consider only in motivational inductions that depart from the standard DS-CPT protocol; in these conditions,

Figure D4a. Interaction between Positive Emotion and Motivational Induction in the Prediction of Response Bias -- High Intrinsic Motivation Condition

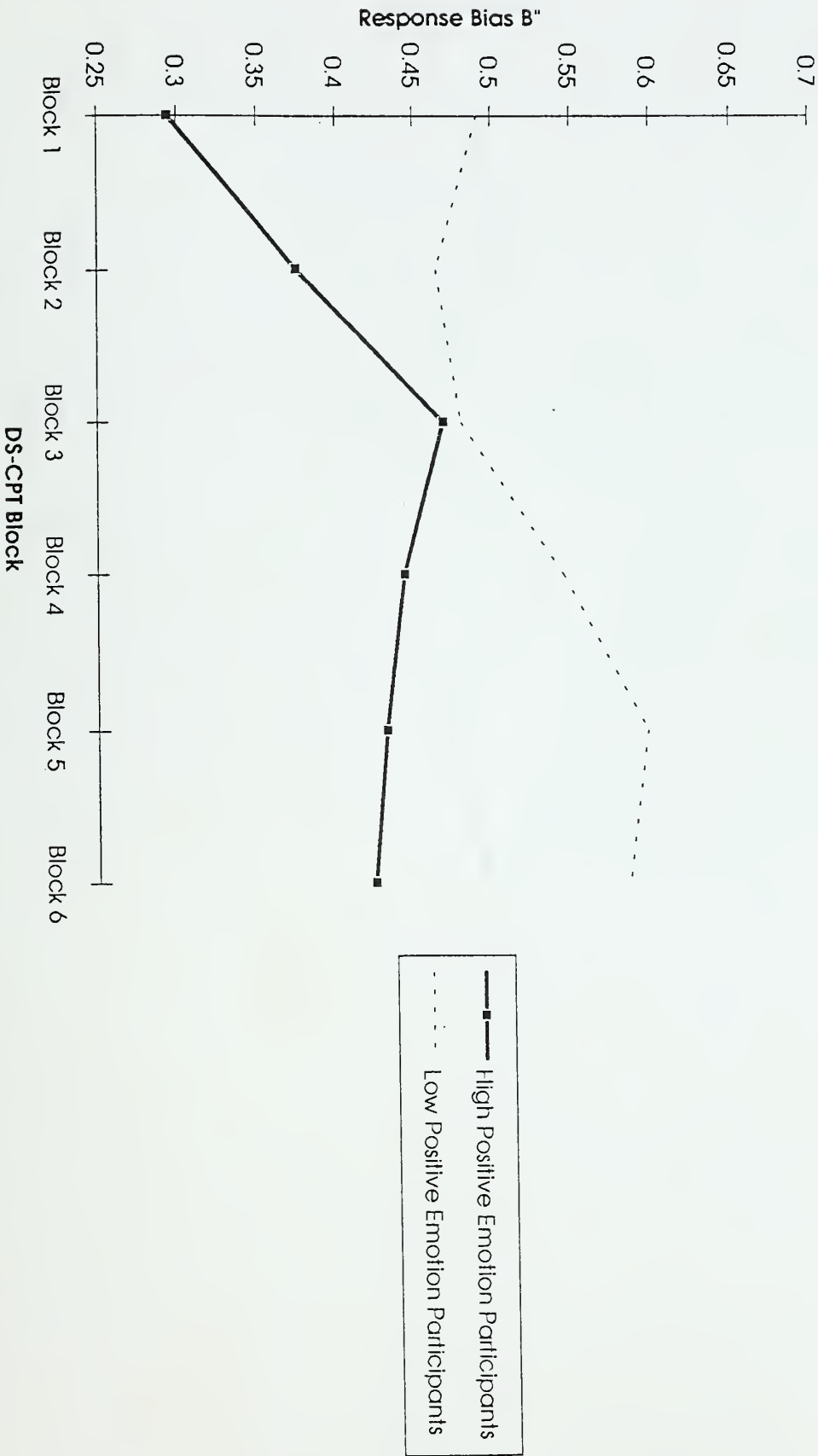


Figure D4b. Interaction between Positive Emotion and Motivational Induction in the Prediction of Response Bias -- Low Autonomy Condition

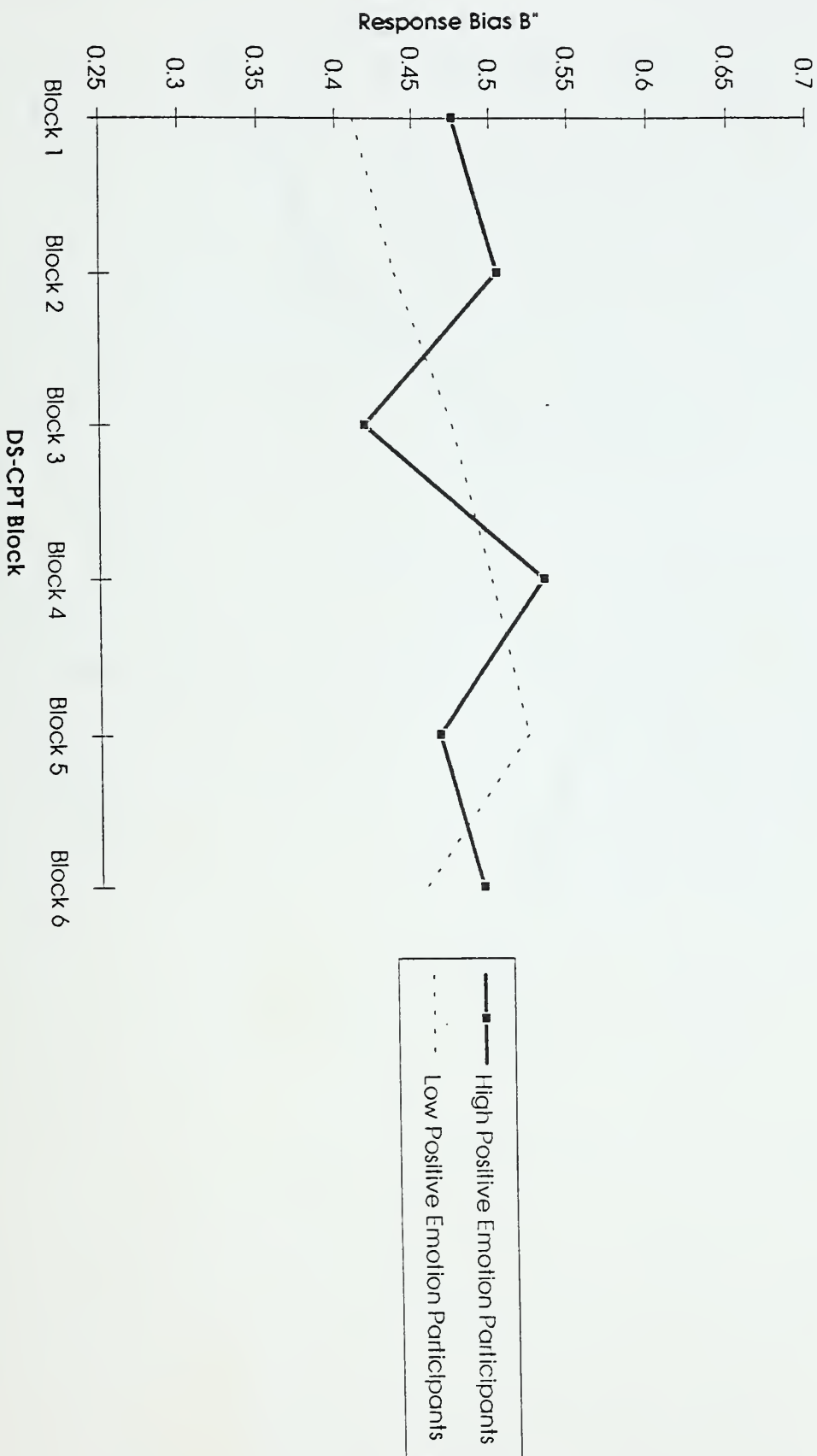
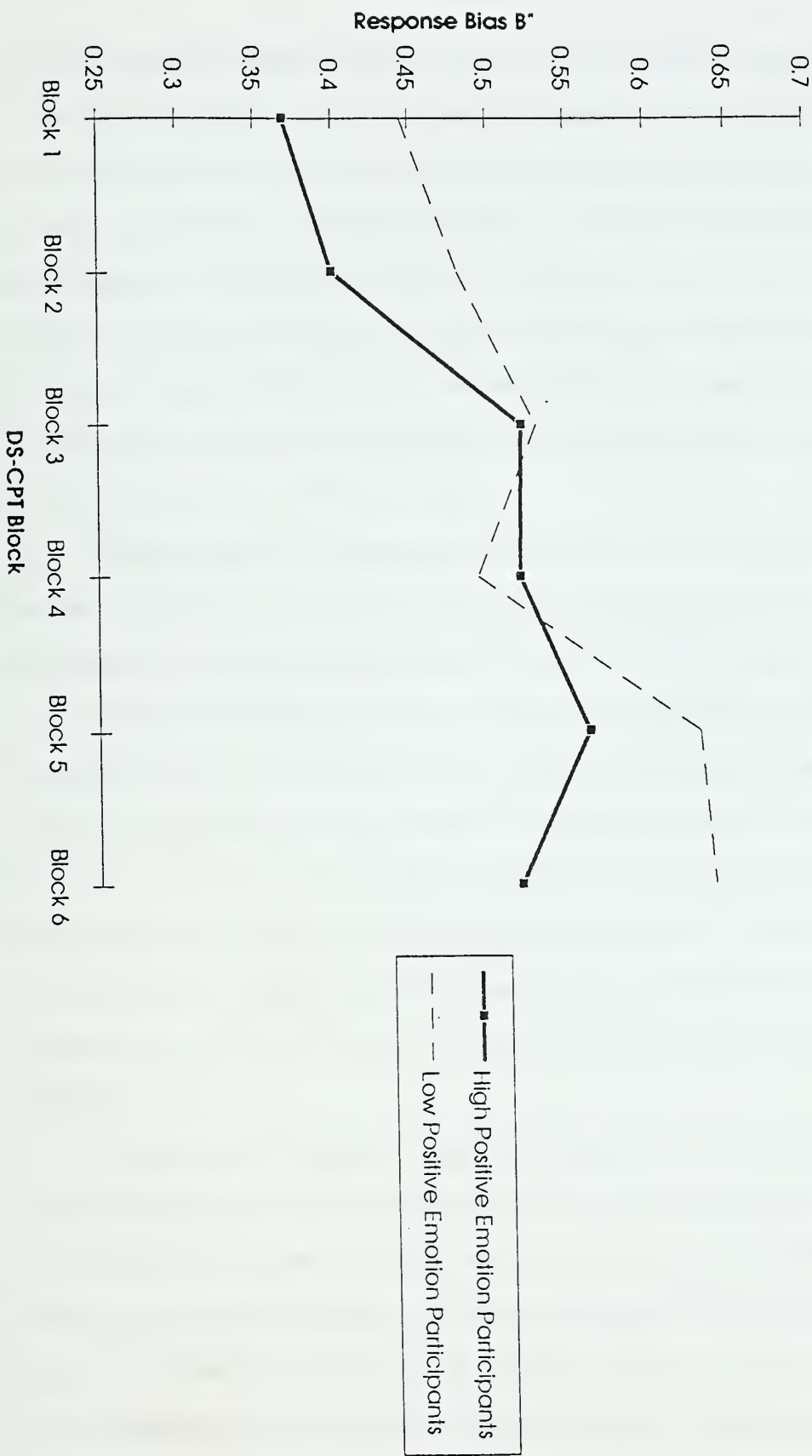


Figure D4c. Interaction between Positive Emotion and Motivational Induction in the Prediction of Response Bias -- Standard Condition



participants reporting higher levels of positive emotion will tend to be more liberal in responding when given latitude to do so (as in the intrinsic motivation induction), but more conservative in responding when their attention is focused on their performance (as in the low autonomy condition). Participants reporting low positive emotion appear to show the opposite pattern. Although these results are intriguing, it should be kept in mind that these emotion x condition interactions were relatively small and did not predict perceptual sensitivity. In addition, the interaction between positive emotion and motivational condition was not significant in predicting the summary response bias scores averaged across the six blocks ($F(2, 185) = 1.94, ns$).

Summary of DS-CPT findings for response bias. Over the entire sample, response bias increased across the six blocks. One parsimonious explanation for this increase in response bias is an expectancy/feedback model (Davies and Parasuraman 1982). According to this model, as participants missed detecting targets during the course of the vigilance task, they revised their response criterion to more conservative levels, in order to adjust for the perceived probability of targets. This increased response bias resulted in fewer hits and false alarms, thus producing additional upward revision of the response criterion, which in turn resulted in still fewer hits and false alarms. Thus, failure to detect all targets leads to a spiral governed by increasingly lower expectancies of targets. However, since the spiral involves both hits and false alarms, it does not affect perceptual sensitivity.

Somewhat more conservative response strategies across all six blocks were associated with higher levels of intrinsic motivation and effort. Overall, the high intrinsic motivation induction appeared to have a moderating effect on the rate at which responding became more conservative with time. Relative to participants in the low autonomy induction, participants in the high intrinsic motivation became more conservative with time, but not as quickly as participants given the standard induction. These findings suggest that

a balanced response strategy may have been most likely in the high intrinsic motivation condition. However, pairwise comparisons of the slopes were significant only between the standard and low autonomy, and not for comparisons with the intrinsic motivation induction group. The significant interaction between motivational induction condition and participant levels of emotion indicates that the effect of motivation induction on response bias depends in important ways on participant characteristics. Participants reporting high levels of positive emotion were most liberal in their response strategy under the intrinsic motivation condition. Compared to participants reporting low levels of positive emotion, high positive emotion participants were also less likely to become conservative with time in the low autonomy condition. Finally, the standard condition appeared to eliminate any relation between positive emotion and response bias.

Again, because all response bias effects took place independently of perceptual sensitivity, caution should be used in interpreting these results. Shifts in response bias accompanied shifts in perceptual sensitivity, but response bias did not bear a predictive relationship to perceptual sensitivity.

REFERENCE LIST

- Aaronson, D., and Watts, B. 1987. Extensions of Grier's computational formulas for A' and B'' to below-chance performance. *Psychological Bulletin*, 102, 439-442.
- Adam, K. S. 1994. Suicidal behavior and attachment: A developmental model. In M. B. Sperling and W. H. Berman (Eds.), *Attachment in adults: Clinical and developmental perspectives*. New York: Guilford Press, pp. 275-298.
- Ainsworth, M. D. S., Blehar, M. C., Waters, E., and Wall, S. 1978. *Patterns of attachment: A psychological study of the strange situation*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Aldenderfer, M. S., and Blashfield, R. K. 1984. *Cluster analysis*. Newbury Park, CA: Sage.
- Allen, J. J., Chapman, L. J., and Chapman, J. P. 1987. Cognitive slippage and depression in hypothetically psychosis-prone college students. *Journal of Nervous and Mental Disease*, 175, 347-353.
- Allen, J. J., Chapman, L. J., Chapman, J. P., Vuchetich, J. P., and Frost, L. A. 1987. Prediction of psychoticlike symptoms in hypothetically psychosis-prone college students. *Journal of Abnormal Psychology*, 96, 83-88.
- American Psychiatric Association 1994. *Diagnostic and statistical manual of mental disorders, 4th ed.* Washington, D.C.: Author.
- Andia, A. M., and Zisook, S. 1991. Gender differences in schizophrenia: A literature review. *Annals of Clinical Psychiatry*, 3, 333-340.
- Andorfer, J. C., Shimkunas, A. M., and Sciarini, J. W. 1975. Neutralization of affective concepts in schizophrenia. *Journal of Abnormal Psychology*, 84, 772-725.
- Asarnow, R. F., and MacCrimmon, D. J. 1978. Residual performance deficit in clinically remitted schizophrenics: A marker of schizophrenia? *Journal of Abnormal Psychology*, 87, 597-608.

- Asarnow, R. F., Steffy, R. A., MacCrimmon, D. J., and Cleghorn, J. M. 1977. An attentional assessment of foster children at risk for schizophrenia. *Journal of Abnormal Psychology*, 86, 267-275.
- Asarnow, R. F., Steffy, R. A., MacCrimmon, D. J., and Cleghorn, J. M. 1978. An attentional assessment of foster children at risk for schizophrenia. In L. C. Wynne, R. L. Cromwell and S. Matthysse (Eds.), *The nature of schizophrenia: New approaches to research and treatment*. New York: John Wiley and Sons, pp. 339-358.
- Bartholomew, K., and Horowitz, L. M. 1991. Attachment styles among young adults: A test of a four-category model. *Journal of Personality and Social Psychology*, 61, 226-244.
- Bateson, G., Jackson, D. D., Haley, J., and Weakland, J. 1956/1972. Toward a theory of schizophrenia. In G. Bateson, *Steps to an ecology of mind*. New York: Balletine Books, pp. 201-227.
- Beech, A., McManus, D., Baylis, G., Tipper, S., and Agar, K. 1991. Individual differences in cognitive processes: Towards an explanation of schizophrenic symptomatology. *British Journal of Psychology*, 82, 417-426.
- Bellak, L. 1979. An idiosyncratic overview. In L. Bellak (Ed.), *Disorders of the schizophrenic syndrome*. New York: Basic Books, pp. 3-24.
- Bellak, L. 1994. The schizophrenic syndrome and attention deficit disorder. *American Psychologist*, 49, 25-29.
- Benedict, R. H. B., Harris, A. E., Markow, T., McCormick, J. A., Nuechterlein, K. H., and Asarnow, R. F. 1994. Effects of attention training on information processing in schizophrenia. *Schizophrenia Bulletin*, 20, 537-546.
- Bentall, R. P. 1990/1992. *Reconstructing schizophrenia*. New York: Routledge, Chapman and Hall.

- Burchinal, M., and Appelbaum, M. L. 1991. Estimating individual developmental functions: Methods and their assumptions. *Child Development*, 62, 32-42.
- Bergum, B. O., and Lehr, D. J. 1963. Effects of authoritarianism on vigilance performance. *Journal of Applied Psychology*, 47, 75-77.
- Berman, K. F., Zee, R. F., and Weinberger, D. R. 1986. Physiologic dysfunction of dorsolateral prefrontal cortex in schizophrenia. *Archives of General Psychiatry*, 43, 126-135.
- Berman, W. H., and Sperling, M. B. 1994. The structure and function of adult attachment. In M. B. Sperling and W. H. Berman (Eds.), *Attachment in adults: Clinical and developmental perspectives*. New York: Guilford, pp. 1-28.
- Bevan, W., and Turner, E. D. 1965. Vigilance performance with a qualitative shift in reinforcers. *Journal of Experimental Psychology*, 70, 83-86.
- Bleuler, E. 1911/1950. *Dementia praecox or the group of schizophrenias*. New York: International Universities Press.
- Böker, W., Brenner, H. D., and Würigler, S. 1989. Vulnerability-linked deficiencies, psychopathology and coping behavior of schizophrenics and their relatives. *British Journal of Psychiatry*, 155 (Suppl. 5), 128-135.
- Bowlby, J. 1980. *Attachment and loss, Vol. III: Loss: Sadness and depression*. New York: Basic Books.
- Bollen, K. A. 1989. *Structural equations with latent variables*. New York: John Wiley.
- Bollen, K. A., and Long, J. S. 1993. Introduction. In K. A. Bollen and J. S. Long (Eds.), *Testing structural equation models*. Newbury Park, CA: Sage, pp. 1-9.
- Bowen, L., Wallace, C. J., Glynn, S. M., Nuechterlein, K. H., Lutzker, J. R., and Kuehnle, T. G. 1994. Schizophrenic individuals' cognitive functioning and performance in interpersonal interactions and skills training procedures. *Journal of Psychiatric Research*, 28, 289-301.

- Brennan, K. A., Shaver, P. R., and Tobey, A. E. 1991. Attachment styles, gender and parental problem drinking. *Journal of Social and Personal Relationships*, 8, 451-466.
- Bretherton, I. 1985. Attachment theory: Retrospect and prospect. *Monographs of the Society for Research in Child Development*, 50, 3-35.
- Brown, G. W., Birley, J. L. T., and Wing, J. K. 1972. Influence of family life on the course of schizophrenic disorders: A replication. *British Journal of Psychiatry*, 121, 241-258.
- Buchsbaum, M. S., Haier, R. J., Sostek, A. J., Weingartner, H., Zahn, T. P., Siever, L. J., Murphy, D. L., and Brody, L. 1985. Attention dysfunction and psychopathology in college men. *Archives of General Psychiatry*, 42, 354-360.
- Buchsbaum, M. S., Murphy, D. L., Coursey, R. D., Lake, C. R., and Zeigler, M. G. 1980. Platelet monoamine oxidase, plasma dopamine-beta-hydroxylase and attention in a "biochemical high risk" sample. *Journal of Psychiatric Research*, 14, 215-224.
- Buchsbaum, M. S., Nuechterlein, K. H., Haier, R. J., Wu, J., Sicotte, N., Hazlett, E., Asarnow, R., Potkin, S., and Guich, S. 1990. Glucose metabolic rate in normals and schizophrenics during the Continuous Performance Test assessed by positron emission tomography. *British Journal of Psychiatry*, 156, 216-227.
- Buchsbaum, M. S., and Sostek, A. J. 1980. An adaptive-rate continuous performance test: Vigilance characteristics and reliability for 400 male students. *Perceptual and Motor Skills*, 51, 707-713.
- Buss, A. H., and Lang, P. J. 1965. Psychological deficit in schizophrenia: I. Affect, reinforcement, and concept attainment. *Journal of Abnormal Psychology*, 70, 2-24.
- Cantor, S. 1988. *Childhood schizophrenia*. New York: Guilford.

- Carr, V., and Wale, J. 1986. Schizophrenia: An information processing model. *Australian and New Zealand Journal of Psychiatry*, 20, 136-155.
- Carson, R. C. 1971. Disordered interpersonal behavior. In W. Hunt (Ed.), *Human behavior and its control*. Cambridge: Schenkman Publishing Co., pp. 134-157.
- Carson, R. C., and Sanislow, C. A., III 1993. The schizophrenias. In H. E. Adams and A. S. Bellak (Eds.), *The clinical psychology handbook*, 2nd ed. New York: Pergamon, pp. 185-199.
- Castle, D. J., Abel, K., Takei, N., and Murray, R. M. 1995. Gender differences in schizophrenia: Hormonal effect or subtypes? *Schizophrenia Bulletin*, 21, 1-12.
- Chapman, L. J., and Chapman, J. P. 1987. The search for symptoms predictive of schizophrenia. *Schizophrenia Bulletin*, 13, 497-503.
- Chapman, L. J., and Chapman, J. P. 1989a. Strategies for resolving the heterogeneity of schizophrenics and their relatives using cognitive measures. *Journal of Abnormal Psychology*, 98, 357-366.
- Chapman, L. J., and Chapman, J. P. 1989b. *Manual for Psychosis-Proneness Scales*. Unpublished manuscript.
- Chapman, L. J., Chapman, J. P., and Miller, E. R. 1982. Reliabilities and intercorrelations of eight measures of proneness to psychosis. *Journal of Consulting and Clinical Psychology*, 50, 187-195.
- Chapman, L. J., Chapman, J. P. and Raulin, M. L. 1976. Scales for physical and social anhedonia. *Journal of Abnormal Psychology*, 85, 374-382.
- Chapman, L. J., Chapman, J. P. and Raulin, M. L. 1978. Body-image aberration in schizophrenia. *Journal of Abnormal Psychology*, 87, 399-407.
- Chapman, L. J., Edell, W. S., and Chapman, J. P. 1980. Physical anhedonia, perceptual aberration, and psychosis proneness. *Schizophrenia Bulletin*, 6, 639-653.

- Chee, P., Logan, G., Schachar, R., Lindsay, P., and Wachsmuth, R. 1989. Effects of event rate and display time on sustained attention in hyperactive, normal, and control children. *Journal of Abnormal Child Psychology*, 17, 371-391.
- Clark, D. C., and Fawcett, J. 1987. Anhedonia, hypohedonia and pleasure capacity in major depressive disorders. In D. C. Clark and J. Fawcett (Eds.), *Anhedonia and affect deficit states*. New York: PMA Publishing Corp., pp. 51-63.
- Coie, J., Terry, R., Lenox, K., Lochman, J., and Hyman, C. In press. Childhood peer rejection and aggression as predictors of stable patterns of adolescent disorder. *Developmental Psychopathology*.
- Cohler, B. J., Grunebaum, H. U., Weiss, J. L., Gamer, E., and Gallant, D. H. 1977. Disturbances of attention among schizophrenic, depressed and well mothers and their children. *Journal of Child Psychology and Psychiatry*, 18, 115-135.
- Collins, N. L., and Read, S. J. 1990a. Adult attachment, working models, and relationship quality in dating couples. *Journal of Personality and Social Psychology*, 58, 644-663.
- Collins, N. L., and Read, S. J. 1990b. *The Revised Adult Attachment Scale*. Unpublished manual, University of Southern California at Los Angeles.
- Comrey, A. L. 1988. Factor-analytic methods of scale development in personality and clinical psychology. *Journal of Consulting and Clinical Psychology*, 56, 754-761.
- Condray, R., and Steinhauer, S. R. 1992. Schizotypal personality disorder in individuals with and without schizophrenic relatives: similarities and contrasts in neurocognitive and clinical functioning. *Schizophrenia Research*, 7, 33-41.
- Cornblatt, B. A., and Erlenmeyer-Kimling, L. 1984. Early attentional predictors of adolescent behavioral disturbances in children at risk for schizophrenia. In N. F. Watt, E. J. Anthony, L. C. Wynne and J. E. Rolf (Eds.), *Children at risk for*

schizophrenia: A longitudinal perspective. New York: Cambridge University Press, pp. 198-211.

- Cornblatt, B. A., and Erlenmeyer-Kimling, L. 1985. Global attentional deviance as a marker of risk for schizophrenia: Specificity and predictive validity. *Journal of Abnormal Psychology*, 94, 470-486.
- Cornblatt, B. A., and Keilp, J. G. 1994. Impaired attention, genetics, and the pathophysiology of schizophrenia. *Schizophrenia Bulletin*, 20, 31-46.
- Cornblatt, B. A., Lenzenweger, M. F., Dworkin, R. H., and Erlenmeyer-Kimling, L. 1985. Positive and negative schizophrenic symptoms, attention, and information processing. *Schizophrenia Bulletin*, 11, 397-407.
- Cornblatt, B. A., Lenzenweger, M. F., Dworkin, R. H., and Erlenmeyer-Kimling, L. 1992. Childhood attentional dysfunctions predict social deficits in unaffected adults at risk for schizophrenia. *British Journal of Psychiatry*, 161 (Suppl. 18), 59-64.
- Cornblatt, B. A., Lenzenweger, M. F., and Erlenmeyer-Kimling, L. 1989. The Continuous Performance Test, Identical Pairs Version (CPT-IP): II. Contrasting attentional profiles in schizophrenic and depressed patients. *Psychiatry Research*, 29, 65-85.
- Cornblatt, B., and Marcuse, Y. 1986. Children at high risk for schizophrenia: Predictions from childhood to adolescence. In L. Erlenmeyer-Kimling and N. E. Miller (Eds.), *Life-span research on the prediction of psychopathology*. Hillsdale, NJ: Lawrence Erlbaum, pp. 101-117.
- Cornblatt, B. A., Risch, N. J., Faris, G., Friedman, D., and Erlenmeyer-Kimling, L. 1988. The Continuous Performance Test, Identical Pairs Version (CPT-IP): I. New findings about sustained attention in normal families. *Psychiatry Research*, 26, 233-238.

- Cornblatt, B. A., Winters, L., and Erlenmeyer-Kimling, L. 1989. Attentional markers of schizophrenia: Evidence from the New York High-Risk Study. In S. C. Schulz and C. A. Tamminga (Eds.), *Schizophrenia: Scientific progress*. New York: Oxford University Press, pp. 83-92.
- Corrigan, P. W., Wallace, C. J., and Green, M. F. 1992. Deficits in social schemata in schizophrenia. *Schizophrenia Research*, 8, 129-135.
- Csikszentmihalyi, M. 1990. *Flow: The psychology of optimal experience*. New York: HarperCollins Publishers.
- Davies, D. R., and Parasuraman, R. 1982. *The psychology of vigilance*. London: Academic Press.
- Deci, E. L., Eghrari, H., Patrick, B. C., and Leone, D. R. 1994. Facilitating internalization: The self-determination theory perspective. *Journal of Personality*.
- Deci, E. L., and Ryan, R. M. 1985a. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.
- Deci, E. L., and Ryan, R. M. 1985b. The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality*, 19, 109-134.
- Deci, E. L., and Ryan, R. M. 1987. The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology*, 53, 1024-1037.
- Dember, W. N., Galinsky, T. L., and Warm, J. S. 1992. The role of choice in vigilance performance. *Bulletin of the Psychonomic Society*, 30, 201-204.
- Diamond, D., and Blatt, S. J. 1994. Internal working models and the representational world in attachment and psychoanalytic theories. In M. B. Sperling and W. H. Berman (Eds.), *Attachment in adults: Clinical and developmental perspectives*. New York: Guilford Press, pp. 31-71.

- Doane, J. A., Jones, J. E., Fisher, L., Ritzler, B., Singer, M. T., and Wynne, L. C. 1982. Parental communication deviance as a predictor of competence in children at risk for adult psychiatric disorder. *Family Process*, 21, 211-223.
- Doane, J. A., West, K. L., Goldstein, M. J., Rodnick, E. H., and Jones, J. E. 1981. Parental communication deviance and affective style. *Archives of General Psychiatry*, 38, 679-685.
- Earle-Boyer, E. A., Serper, M. R., Davidson, M., and Harvey, P. D. 1991. Continuous Performance Tests in schizophrenic patients: Stimulus and medication effects on performance. *Psychiatry Research*, 37, 47-56.
- Eckblad, M., and Chapman, L. J. 1983. Magical ideation as an indicator of schizotypy. *Journal of Consulting and Clinical Psychology*, 51, 215-225.
- Edell, W. S., and Chapman, L. J. 1979. Anhedonia, perceptual aberration, and the Rorschach. *Journal of Consulting and Clinical Psychology*, 47, 377-384.
- Erickson, M., Sroufe, L., and Egeland, B. 1985. The relationship between quality of attachment and behavior problems in preschool in a high-risk sample. In I. Bretherton and E. Waters (Eds.), *Growing points of attachment theory and research. Monographs for the Society for Research in Child Development*, 50 (1-2, Serial No. 209), pp. 147-166.
- Erickson, W. D., Yellin, A. M., Hopwood, J. H., Realmuto, G. M., and Greenberg, L. M. 1984. The effects of neuroleptics on attention in adolescent schizophrenics. *Biological Psychiatry*, 19, 745-753.
- Erlenmeyer-Kimling, L., and Cornblatt, B. 1978. Attentional measures in a study of children at high-risk for schizophrenia. *Journal of Psychiatric Research*, 14, 93-98.

- Erlenmeyer-Kimling, L., and Cornblatt, B. 1987. High-risk research in schizophrenia: A summary of what has been learned. *Journal of Psychiatric Research*, 21, 401-411.
- Erlenmeyer-Kimling, L., and Cornblatt, B. 1992. A summary of attentional findings in the New York High-Risk Project. *Journal of Psychiatric Research*, 26, 405-426.
- Erlenmeyer-Kimling, L. Cornblatt, B., Friedman, D., Marcuse, Y., Rutschmann, J., Simmens, S., and Devi, S. 1982. Neurological, electrophysiological, and attentional deviations in children at risk for schizophrenia. In F. A. Henn and H. A. Nasrallah (Eds.), *Schizophrenia as a brain disease*. New York: Oxford University Press, pp. 61-98.
- Erlenmeyer-Kimling, L., Cornblatt, B., and Golden, R. R. 1983. Early indicators of vulnerability to schizophrenia in children at high genetic risk. In S. B. Guze, F. J. Earls and J. E. Barrett (Eds.), *Childhood psychopathology and development*. New York: Raven Press, pp. 247-264.
- Erlenmeyer-Kimling, L., Cornblatt, B. A., Rock, S. R., Bell, M., and West, A. 1993. The New York High-Risk Project: Anhedonia, attentional deviance, and psychopathology. *Schizophrenia Bulletin*, 19, 141-153.
- Erlenmeyer-Kimling, L., Golden, R. R., and Cornblatt, B. A. 1989. A taxometric analysis of cognitive and neuromotor variables in children at risk for schizophrenia. *Journal of Abnormal Psychology*, 98, 203-208.
- Everett, J., LaPlante, L., and Thomas, J. 1989. The selective attention deficit in schizophrenia: Limited resources of cognitive fatigue? *Journal of Nervous and Mental Disease*, 177, 735-738.
- Feinman, S. 1983. How does a baby socially refer? Two views of social referencing: A reply to Campos. *Merrill-Palmer Quarterly*, 29, 467-471.

- Feeney, J. A., Noller, P., and Hanrahan, M. 1994. Assessing adult attachment. In M. B. Sperling and W. H. Berman (Eds.), *Attachment in adults: Clinical and developmental perspectives*. New York: Guilford, pp. 128-152.
- Fish, B. 1977. Neurobiological antecedents of schizophrenia in children: Evidence for an inherited, congenital, neurointegrative defect. *Archives of General Psychiatry*, 34, 1297-1313.
- Flack, W. F., Miller, D. R., and Weiner, M. (Eds.) 1991. *What is schizophrenia?* New York: Springer-Verlag.
- Fredrickson, B. L., and Roberts, T.-A. 1994. *Objectification theory: An explanation for women's lived experience and mental health risks*. Unpublished manuscript.
- Freedman, R. V., and Chapman, L. J. 1973. Early subjective experience in schizophrenic episodes. *Journal of Abnormal Psychology*, 50, 45-52.
- Frith, C. D. 1979. Consciousness, information processing and schizophrenia. *British Journal of Psychiatry*, 134, 225-235.
- Fromm-Reichmann, F. 1948. Notes on the development of treatment of schizophrenics by psychoanalytic psychology. *Psychiatry*, 2, 263-273.
- Garmezy, N. 1994. Reflections and commentary on risk, resilience, and development. In R. J. Haggerty, L. R. Sherrod, N. Garmezy, and M. Rutter (Eds.), *Stress, risk, and resilience in children and adolescents*. Cambridge: University of Cambridge Press, pp. 1-18.
- Garmezy, N., Masten, A. S., and Tellegen, A. 1984. The study of stress and competence in children: A building block for developmental psychopathology. *Child Development*, 55, 97-111.
- Gjerde, P. F. 1983. Attentional capacity dysfunction and arousal in schizophrenia. *Psychological Bulletin*, 93, 57-72.

- Goldstein, J. M. and Kreisman, D. 1988. Gender, family environment and schizophrenia. *Psychological Medicine*, 18, 861-872.
- Goldstein, M. J. 1985. Family factors that antedate the onset of schizophrenia and related disorders: The results of a fifteen year prospective longitudinal study. *Acta Psychiatrica Scandinavica*, 71 (Suppl. 319), 7-18.
- Goldstein, M. J. 1990. Family relations as risk factors for the onset and course of schizophrenia. In J. Rolf, A. S. Masten, D. Cicchetti, K. H. Nuechterlein, and S. Weintraub (Eds.), *Risk and protective factors in the development of psychopathology*. Cambridge, UK: Cambridge University Press, pp. 408-423.
- Goldstein, M. J., and Rodnick, E. H. 1975. The family's contribution to the etiology of schizophrenia: Current status. *Schizophrenia Bulletin*, 1, 48-63.
- Gottesman, I. I. 1991. *Schizophrenia genesis: The origins of madness*. New York: W. H. Freeman and Company.
- Grolnick, W. S., and Ryan, R. M. 1987. Autonomy in children's learning: An experimental and individual difference investigation. *Journal of Personality and Social Psychology*, 52, 890-898.
- Green, M. F., Satz, P., Ganzell, S., and Vaclav, J. F. 1992. Wisconsin Card Sorting Test performance in schizophrenia: Remediation of a stubborn deficit. *American Journal of Psychiatry*, 149, 62-67.
- Green, M. F., Ganzell, S., Satz, P., and Vaclav, J. F. 1990. Teaching the Wisconsin Card Sorting Test to schizophrenic patients. (Letter to the editor.) *Archives of General Psychiatry*, 47, 91-92.
- Grier, J. B. 1971. Nonparametric indexes for sensitivity and bias: Computing formulas. *Psychological Bulletin*, 75, 424-429.

- Grove, W. M., Lebow, B. S., Clementz, B. A., Cerri, A., Medus, C., and Iacono, W. G. 1991. Familial prevalence and coaggregation of schizotypy indicators: A multitrait family study. *Journal of Abnormal Psychology*, 100, 115-121.
- Grunebaum, H., Cohler, B. J., Kauffman, C., and Gallant, D. 1978. Children of depressed and schizophrenic mothers. *Child Psychiatry and Human Development*, 8, 219-228.
- Grunebaum, H., Weiss, J. L., Gallant, D., and Cohler, B. J. 1974. Attention in young children of psychotic mothers. *American Journal of Psychiatry*, 131, 887-891.
- Guelfi, G. P., Faustman, W. O., and Csernansky, J. G. 1989. Independence of positive and negative symptoms in a population of schizophrenic patients. *Journal of Nervous and Mental Disease*, 177, 285-290.
- Guich, S. M., Buchsbaum, M. S., Burgwald, L., Wu, J., Haier, R., Asarnow, R., Nuechterlein, K., and Potkin, S. 1989. Effect of attention on frontal distribution of delta activity and cerebral metabolic rate in schizophrenia. *Schizophrenia Research*, 2, 439-448.
- Gureje, O. 1991. Gender and schizophrenia: age at onset and sociodemographic attributes. *Acta Psychiatrica Scandinavica*, 83, 402-405.
- Hain, C., Maier, W., Klinger, T., and Franke, P. 1993. Positive/negative symptomatology and experimental measures of attention in schizophrenic patients. *Psychopathology*, 26, 62-68.
- Halcomb, C. G., and Blackwell, P. J. 1969. Motivation and the human monitor. I: The effect of contingent credit. *Perceptual and Motor Skills*, 31, 145-146.
- Hamilton, J. A., Haier, R. J., and Buchsbaum, M. S. 1984. Intrinsic enjoyment and boredom coping scales: Validation with personality, evoked potential and attention measures. *Personality and Individual Differences*, 5, 183-193.

- Harvey, P. D., Keefe, R. S. E., Moskowitz, J., Putnam, K. M., Mohs, R. C., and Davis, K. L. 1990. Attentional markers of vulnerability to schizophrenia: Performance of medicated and unmedicated patients and normals. *Psychiatry Research*, 33, 179-188.
- Hazan, C., and Shaver, P. 1987. Romantic love conceptualized as an attachment process. *Journal of Personality and Social Psychology*, 52, 511-524.
- Hazlett, E. A., Dawson, M. E., Buchsbaum, M. S. and Nuechterlein, K. H. 1993. Reduced regional brain glucose metabolism assessed by positron emission tomography in electrodermal nonresponder schizophrenics: A pilot study. *Journal of Abnormal Psychology*, 102, 39-46.
- Herman, J., Mirsky, A. F., Ricks, N. C. and Gallant, D. 1977. Behavioral and electrographic measures of attention in children at risk for schizophrenia. *Journal of Abnormal Psychology*, 86, 27-33.
- Hirsh, S. R., and Leff, J. P. 1975. *Abnormalities in parents of schizophrenics*. London: Oxford University Press.
- Hogan, M. J. 1966. Influence of motivation on reactive inhibition in extraversion-introversion. *Perceptual and Motor Skills*, 22, 187-192.
- Holzman, P. S. 1990. Schizophrenia: A new model of its transmission and its variations. In J. Rolf, A. S. Masten, D. Cicchetti, K. H. Nuechterlein, and S. Weintraub (Eds.), *Risk and protective factors in the development of psychopathology*. Cambridge, UK: Cambridge University Press, pp. 480-496.
- Holzman, P. S., Levy, D. L., and Proctor, L. R. 1976. Smooth pursuit eye movements, attention, and schizophrenia. *Archives of General Psychiatry*, 33, 1415-1420.
- Holzman, P. S., Proctor, L. R., Levy, D. L., Yasillo, N. J., Metzger, H. K., and Hurt, S. W. 1974. Eye-tracking dysfunctions in schizophrenics patients and their relatives. *Archives of General Psychiatry*, 31, 143-151.

- Hornik, R., and Gunnar, M. R. 1988. A descriptive analysis of infant social referencing. *Child Development*, 59, 626-634.
- Huhtaniemi, P., Haier, R. J., Fedio, P. and M. S. Buchsbaum 1983. Neuropsychological characteristics of college males who show attention dysfunction. *Perceptual and Motor Skills*, 57, 399-406.
- Hunter, J. E., and Schmidt, F. L. 1990. *Methods of meta-analysis: Correcting error and bias in research findings*. Newbury Park, CA: Sage Publications.
- Jacobsen, T., Edelstein, W., and Hofmann, V. 1994. A longitudinal study of the relation between representations of attachment in childhood and cognitive functioning in childhood and adolescence. *Developmental Psychology*, 30, 112-124.
- Jöreskog, K. G. 1993. Testing structural equation models. In K. A. Bollen and J. S. Long (Eds.), *Testing structural equation models*. Newbury Park, CA: Sage, pp. 1-9.
- Kirkpatrick, B., and Buchanan, R. W. 1990. Anhedonia and the deficit syndrome of schizophrenia. *Psychiatry Research*, 31, 25-30.
- Klinnert, M. D., Emde, R. N., Butterfield, P., and Campos, J. J. 1986. Social referencing: The infant's use of emotional signals from a friendly adult with mother present. *Developmental Psychology*, 22, 427-432.
- Knight, R. A., Elliott, D. S., and Freedman, E. G. 1985. Short-term visual memory in schizophrenics. *Journal of Abnormal Psychology*, 94, 427-442.
- Kobak, R. R., and Sceery, A. 1988. Attachment in late adolescence: Working models, affect regulation, and representations of self and others. *Child Development*, 59, 135-146.
- Koestner, R., Zuckerman, M., and Koestner, J. 1987. Praise, involvement and intrinsic motivation. *Journal of Personality and Social Psychology*, 53, 383-390.

- Kopfstein, J. H. and Neale, J. M. 1972. A multivariate study of attention dysfunction in schizophrenia. *Journal of Abnormal Psychology*, 80, 294-298.
- Kornetsky, C. 1972. The use of a simple test of attention as measure of drug effects in schizophrenic patients. *Psychopharmacologia*, 24, 99-106.
- Kornetsky, C. and Mirsky, A. F. 1966. On certain psychopharmacological and physiological differences between schizophrenics and normal persons. *Psychopharmacologia*, 8, 309-318.
- Kornetsky, C. and Orzack, M. H. 1964. A research note on some of the critical factors on the dissimilar effects of chlorpromazine and secobarbital on the Digit Symbol Substitution and Continuous Performance Tests. *Psychopharmacologia*, 6, 79-86.
- Kornetsky, C. and Orzack, M. H. 1978. Physiologic and behavioral correlates of attention dysfunction in schizophrenic patients. In L. C. Wynne, R. L. Cromwell and S. Matthysse (Eds.), *The nature of schizophrenia: New approaches to research and treatment*. New York: John Wiley and Sons, pp. 196-204.
- Korfine, L., and Lenzenweger, M. F. 1995. The taxonicity of schizotypy: A replication. *Journal of Abnormal Psychology*, 104, 26-31.
- Latz, A. and Kornetsky, C. 1965. The effects of chlorpromazine and secobarbital under two conditions of reinforcement on the performance of chronic schizophrenic subjects. *Psychopharmacologia*, 7, 77-88.
- Leff, J., and Vaughn, C. 1985. *Expressed emotion in families: Its significance for mental illness*. New York: Guilford.
- Lencz, R., Raine, A., Scerbo, A., Redmon, M., Brodish, S., Holt, L., and Bird, L. 1993. Impaired eye tracking in undergraduates with schizotypal personality disorder. *American Journal of Psychiatry*, 150, 152-154.
- Lenzenweger, M. F., Cornblatt, B. A., and Putnick, M. 1991. Schizotypy and sustained attention. *Journal of Abnormal Psychology*, 100, 84-89.

- Lenzenweger, M. F., and Korfine, L. 1992. Confirming the latent structure and base rate of schizotypy: A taxometric analysis. *Journal of Abnormal Psychology*, 101, 567-571.
- Lenzenweger, M. F., and Moldin, S. O. 1990. Discerning the latent structure of hypothetical psychosis proneness through admixture analysis. *Psychiatry Research*, 33, 243-257.
- Lidz, T., Cornelison, A., Terry, D., and Fleck, S. 1958. Intrafamilial environment of the schizophrenic patient: VI. The transmission of irrationality. *Archives of Neurology and Psychiatry*, 79, 305-316.
- Long, J. S. 1983. *Confirmatory factor analysis*. Newbury Park, CA: Sage.
- Lucaccini, L. F., Freedy, A., and Lyman, J. 1968. Motivational factors in vigilance: Effects of instructions on performance in a complex vigilance task. *Perceptual and Motor Skills*, 26, 783-786.
- MacCallum, R. C., Wegener, D. T., Uchino, B. N., and Fabrigar, L. R. 1993. The problem of equivalent models in applications of covariance structure analysis. *Psychological Bulletin*, 114, 185-199.
- Macmillan, N. A., and Creelman, C. D. 1991. *Detection theory: A user's guide*. New York: Cambridge University Press.
- Madden, D. J. 1992. Four to ten milliseconds per year: Age-related slowing of visual word identification. *Journal of Gerontology: Psychological Sciences*, 47, 59-68.
- Main, M., and Cassidy, J. 1988. Categories of response to reunion with the parent at age 6: Predictable from infant attachment classifications and stable over a 1-month period. *Developmental Psychology*, 24, 415-426.

- Main, M., Kaplan, N., and Cassidy, J. 1985. Security in infancy, childhood, and adulthood: A move to the level of representation. *Monographs of the Society for Research in Child Development*, 50, 66-104.
- Meehl, P. 1962. Schizotaxia, schizotypy, schizophrenia. *American Psychologist*, 17, 827-838.
- Meehl, P. 1964. *Manual for use with checklist of schizotypic signs*. University of Minnesota: Unpublished manuscript.
- Meehl, P. 1975/1987. Hedonic capacity: Some conjectures. In D. C. Clark and J. Fawcett (Eds.), *Anhedonia and affect deficit states*. New York, PMA Publishing Corp., pp. 33-45.
- Meehl, P. 1987. "Hedonic capacity" ten years later: Some clarifications. In D. C. Clark and J. Fawcett (Eds.), *Anhedonia and affect deficit states*. New York, PMA Publishing Corp., pp. 47-50.
- Meehl, P. 1989. Schizotaxia revisited. *Archives of General Psychiatry*, 46, 935-944.
- Meehl, P. 1990. Toward an integrated theory of schizotaxia, schizotypy and schizophrenia. *Journal of Personality Disorders*, 4, 1-99.
- Meehl, P. 1995. Bootstraps taxometrics: Solving the classification problem in psychopathology. *American Psychologist*, 50, 266-275.
- Mishler, E. G., and Waxler, N. E. (Eds.) 1968. *Family processes and schizophrenia*. New York: Science House.
- Moldin, S. O., Gottesman, I. I., and Erlenmeyer-Kimling, L. 1987. Search for the psychometric boundaries of schizophrenia: Evidence from the New York High-Risk Study. *Journal of Abnormal Psychology*, 96, 354-363.
- Moldin, S. O., Gottesman, I. I., Erlenmeyer-Kimling, L., and Cornblatt, B. A. 1990. Psychometric deviance in offspring at risk for schizophrenia: I. Initial delineation of a distinct subgroup. *Psychiatry Research*, 32, 297-310.

- Mussgay, L., and Hertwig, R. 1990. Signal detection indices in schizophrenics on a visual, auditory, and bimodal Continuous Performance Test. *Schizophrenia Research*, 3, 303-310.
- Neale, J. M., Oltmanns, T. F., and Harvey, P. D. 1985. The need to relate cognitive deficits to specific behavioral referents of schizophrenia. *Schizophrenia Bulletin*, 11, 286-291.
- Nesselroade, J. R. 1994. Exploratory factor analysis with latent variables and the study of processes of development and change. In A. von Eye and C. B. Clogg (Eds.), *Latent variables analysis*. Thousand Oaks, CA: Sage, pp. 131-154.
- Nestor, P. G., Faux, S. F., McCarley, R. W., Sands, S. F., Horvath, T. B., and Peterson, A. 1991. Neuroleptics improve sustained attention in schizophrenia: A study using signal detection theory. *Neuropsychopharmacology*, 4, 145-149.
- Nestor, P. G., Faux, S. F., McCarley, R. W., Shenton, M. E., and Sands, S. F. 1990. Measurement of visual sustained attention in schizophrenia using signal detection analysis and a newly developed computerized CPT task. *Schizophrenia Research*, 3, 329-332.
- Nuechterlein, K. H. 1977. Reaction time and attention in schizophrenia: A critical evaluation of the data and theories. *Schizophrenia Bulletin*, 3, 373-428.
- Nuechterlein, K. H. 1983. Signal detection in vigilance tasks and behavioral attributes among offspring of schizophrenic mothers and among hyperactive children. *Journal of Abnormal Psychology*, 92, 4-28.
- Nuechterlein, K. H. 1984a. Perspectives on future studies of attentional functioning in children at risk for schizophrenia. In N. F. Watt, E. J. Anthony, L. C. Wynne and J. E. Rolf (Eds.), *Children at risk for schizophrenia: A longitudinal perspective*. New York: Cambridge University Press, pp. 327-332.

- Nuechterlein, K. H. 1984b. Sustained attention among children vulnerable to adult schizophrenia and among hyperactive children. In N. F. Watt, E. J. Anthony, L. C. Wynne and J. E. Rolf (Eds.), *Children at risk for schizophrenia: A longitudinal perspective*. New York: Cambridge University Press, pp. 304-311.
- Nuechterlein, K. H. 1985. Converging evidence for vigilance deficit as a vulnerability indicator for schizophrenic disorders. In M. Alpert (Ed.), *Controversies in schizophrenia: Changes and constancies*. New York: Guilford, pp. 175-198.
- Nuechterlein, K. H. 1986. Annotation: Childhood precursors of adult schizophrenia. *Journal of Child Psychology and Psychiatry*, 27, 133-144.
- Nuechterlein, K. H. 1987. Vulnerability models for schizophrenia: State of the art. In H. Häfner, W. F. Gattaz, and W. Janzarik (Eds.), *Search for the causes of schizophrenia*. New York: Springer-Verlag, pp. 297-316.
- Nuechterlein, K. H. 1991. Vigilance in schizophrenia and related disorders. In S. R. Steinhauser, J. H. Gruzelier and J. Zupin (Eds.), *Handbook of schizophrenia, Vol. 5: Neuropsychology, psychophysiology and information processing*. Amsterdam: Elsevier Science Publishers, pp. 397-433.
- Nuechterlein, K. H., Buchsbaum, M. S., and Dawson, M. E. 1994. Neuropsychological vulnerability to schizophrenia. In A. S. David and J. C. Cutting (Eds.), *The neuropsychology of schizophrenia*. Hillsdale: Lawrence Erlbaum Associates, pp. 53-77.
- Nuechterlein, K. H., and Asarnow, R. 1992/1993. *Degraded Stimulus Continuous Performance Test, Version 6.07*. Los Angeles: University of California at Los Angeles Clinical Research Center for the Study of Schizophrenia.
- Nuechterlein, K. H. and Dawson, M. E. 1984a. A heuristic vulnerability/stress model of schizophrenia episodes. *Schizophrenia Bulletin*, 10, 300-312.

- Nuechterlein, K. H. and Dawson, M. E. 1984b. Information processing and attentional functioning in the developmental course of schizophrenic disorders. *Schizophrenia Bulletin*, 10, 160-203.
- Nuechterlein, K. H., Edell, W. S., Norris, M. and Dawson, M. E. 1986. Attentional vulnerability indicators, thought disorder, and negative symptoms. *Schizophrenia Bulletin*, 12, 408-426.
- Nuechterlein, K. H., Garmezy, N. and Devine, V. T. 1989. Sustained, focused attention under high processing loads: Relevance to vulnerability to schizophrenia. In S. C. Schulz and C. A. Tamminga (Eds.), *Schizophrenia: Scientific progress*. New York: Oxford University Press, pp. 95-102.
- Nuechterlein, K. H., Goldstein, M. J., Ventura, J., Dawson, M. E. and Doane, J. A. 1989. Patient-environment relationships in schizophrenia: Information Processing, communication deviance, autonomic arousal, and stressful life events. *British Journal of Psychiatry*, 155 (Suppl. 5), 84-89.
- Nuechterlein, K. H., Parasuraman, J. and Jiang, Q. 1983. Visual sustained attention: Image degradation produces rapid sensitivity decrement over time. *Science*, 20, 327-329.
- Nuechterlein, K. H., Phipps-Yonas, S., Driscoll, R. and Garmezy, N. 1990. Vulnerability factors in children at risk: anomalies in attentional functioning and social behavior. In J. Rolf, A. S. Masten, D. Cicchetti, K. H. Nuechterlein, and S. Weintraub (Eds.), *Risk and protective factors in the development of psychopathology*. Cambridge, UK: Cambridge University Press, pp. 445-479.
- Obiols, J. E., Clos, M., García-Domingo, E. C. M., de Trinchería, I., and Doménech, E. 1992. Sustained attention deficit in young schizophrenic and schizotypic men. *Psychological Reports*, 71, 1131-1136.

- Orzack, M. H., and Kornetsky, C. 1966. Attention dysfunction in chronic schizophrenia. *Archives of General Psychiatry*, 14, 323-326.
- Orzack, M. H., and Kornetsky, C. 1971. Environmental and familial predictors of attention behavior in chronic schizophrenics. *Journal of Psychiatric Research*, 9, 21-29.
- Orzack, M. H., Kornetsky, C., and Freeman, H. 1967. The effects of daily administration of carphenazine on attention in the schizophrenic patient. *Psychopharmacologia*, 11, 31-38.
- Parasuraman, R. 1979. Memory load and event rate control sensitivity decrements in sustained attention. *Science*, 205, 924-927.
- Pascal, G. R., and Swenson, C. 1952. Learning in mentally ill patients under conditions of unusual motivation. *Journal of Personality*, 21, 240-249.
- Pigache, R. M. 1976. Comparison of scoring methods for tests of attention, including an error index for use with schizophrenic patients. *Perceptual and Motor Skills*, 1976, 243-253.
- Plant, R. W., and Ryan, R. M. 1985. Intrinsic motivation and the effects of self-consciousness, self-awareness, and ego-involvement: An investigation of internally controlling styles. *Journal of Personality*, 53, 435-449.
- Putallaz, M., Costanzo, P. R., and Klein, T. P. 1993. Parental childhood social experiences and their effects on children's relationships. In S. Duke (Ed.), *Learning about relationships*. Newbury Park: Sage, pp. 63-97.
- Putz, V. R. 1975. The effects of different modes of supervision on vigilance behavior. *British Journal of Psychology*, 66, 157-160.
- Rathunde, K., Hamilton, J., and Csikszentmihalyi, M. 1993. Socio-motivational effects on cognitive performance and brain electrical activity in gifted adolescents. Unpublished manuscript.

- Rodnick, E. H., and Shakow, M. A. 1940. Set in the schizophrenic as measured by a composite reaction time index. *American Journal of Psychiatry*, 47, 214-225.
- Rosvold, H. E., Mirsky, A., Sarason, I. Bransome, E.D., and Beck, L. H. 1956. A continuous performance test of brain damage. *Journal of Consulting Psychology*, 20, 343-350.
- Rothbard, J. C., and Shaver, P. R. 1994. Continuity of attachment across the life span. In M. B. Sperling and W. H. Berman (Eds.), *Attachment in adults: Clinical and developmental perspectives*. New York: Guilford, pp. 31-71.
- Rutschmann, J. Cornblatt, B., and Erlenmeyer-Kimling, L. 1977. Sustained attention in children at risk for schizophrenia: Report on a Continuous Performance Test. *Archives of General Psychiatry*, 34, 571-575.
- Rutschmann, J. Cornblatt, B., and Erlenmeyer-Kimling, L. 1986. Sustained attention in children at risk for schizophrenia: Findings with two visual Continuous Performance Tests in a new sample. *Journal of Abnormal Child Psychology*, 14 , 365-385.
- Rutter, M. 1990. Psychosocial resilience and protective mechanisms. In J. Rolf, A. S. Masten, D. Cicchetti, K. H. Nuechterlein, and S. Weintraub (Eds.), *Risk and protective factors in the development of psychopathology*. Cambridge: Cambridge University Press, pp. 181-214.
- Ryan, R. M. 1982. Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, 43, 450-461.
- Ryan, R. M., and Deci, E. L. 1985. The "Third Selective Paradigm" and the role of human motivation in cultural and biological selection: A response to Csikszentmihalyi and Massimini. *New Ideas in Psychology*, 3, 259-264.

- Ryan, R. M., and Deci, E. L. 1989. Bridging the research traditions of task/ego involvement and intrinsic/extrinsic motivation: Comment on Butler (1987). *Journal of Educational Psychology*, 81, 265-268.
- Ryan, R. M., Koestner, R., and Deci, E. L. 1991. Ego-involved persistence: When free-choice behavior is not intrinsically motivated. *Motivation and Emotion*, 15, 185-205.
- Ryan, R. M., Mims, V., and Koestner, R. 1983. Relation of reward contingency and interpersonal context to intrinsic motivation: A review and test using cognitive evaluation theory. *Journal of Personality and Social Psychology*, 45, 736-750.
- Saccuzzo, D. P. 1986. An information processing interpretation of theory and research in schizophrenia. In R. E. Ingram (Ed.), *Information processing approaches to clinical psychology*. Orlando: Academic Press (pp. 195-214).
- SAS Institute, Inc. 1990 *SAS/STAT User's Guide, Version 6, 4th Ed.* Cary: Author.
- Schuck, J. R., and Lee, R. G. 1989. Backward masking, information processing, and schizophrenia. *Schizophrenia Bulletin*, 15, 491-500.
- Schwarzman, A. E., Ledingham, J. E., and Serbin, L. A. (1985). Identification of children at risk for adult schizophrenia: A longitudinal study. *International Review of Applied Psychology*, 34, 363-380.
- Searles, H. F. 1959/1988. The effort to drive the other person crazy -- an element in the aetiology and psychotherapy of schizophrenia. In H. F. Searles, *Collected papers on schizophrenia and related subjects*. Madison, CT: International Universities Press, pp. 254-283.
- Searles, H. F. 1959/1988. The evolution of the mother transference in psychotherapy with the schizophrenic patient. In H. F. Searles, *Collected papers on schizophrenia and related subjects*. Madison, CT: International Universities Press, pp. 349-380.

- Serper, M. R., Bergman, R. L., and Harvey, P. D. 1990. Medication may be required for the development of automatic information processing in schizophrenia. *Psychiatry Research*, 32, 281-288.
- Shagass, C., Roemer, R. A., and Amadeo, M. 1976. Eye-tracking performance and engagement of attention. *Archives of General Psychiatry*, 33, 121-125.
- Shakow, D. 1962. Segmental set: A theory of the formal psychological deficit in schizophrenia. *Archives of General Psychiatry*, 6, 17-33.
- Siever, L. J., Keefe, R., Bernstein, D. P., Coccato, E. F., Klar, H. M., Zemishlany, Z., Peterson, A. E., Davidson, M., Mahon, T., Horvath, T., and Mohs, R. 1990. Eye tracking impairment in clinically identified patients with schizotypal personality disorder. *American Journal of Psychiatry*, 147, 740-745.
- Singer, M. R., and Wynne, L. C. 1965a. Thought disorder and family relations of schizophrenics: III. Methodology using projective techniques. *Archives of General Psychiatry*, 12, 187-200.
- Singer, M. R., and Wynne, L. C. 1965b. Thought disorder and family relations of schizophrenics: IV. Results and implications. *Archives of General Psychiatry*, 12, 201-212.
- Sipowicz, R. R., Ware, J. R., and Baker, R. A. 1962. The effects of reward and knowledge of results on the performance of a simple vigilance task. *Journal of Experimental Psychology*, 64, 58-61.
- Spitzer, R. L., Williams, J. B. W., Gibbon, M., and First, M. B. 1988. *Structured Clinical Interview for DSM-III-R -- Patient Version*. New York: New York State Psychiatric Institute Biometrics Research Department.
- Spring, B., Lemon, M., and Fergusson, P. 1990. Vulnerabilities to schizophrenia: Information processing markers. In E. R. Straube and K. Hahlweg (Eds.),

- Schizophrenia: Concepts, vulnerability, and intervention*. Berlin: Springer-Verlag, pp. 97-114.
- Spohn, H. E., Lacoursiere, R. B., Thompson, K., and Coyne, L. 1977. Phenothiazine effects on psychophysiological dysfunction in chronic schizophrenics. *Archives of General Psychiatry*, 34, 633-644.
- Steinhauer, S. R., Zubin, J., Condray, R., Shaw, D. B., Peters, J. L., and van Kammen, D. P. 1991. Electrophysiological and behavioral signs of attentional disturbance in schizophrenics and their siblings. In C. A. Tamminga and S. C. Schulz (Eds.), *Advances in neuropsychiatry and psychopharmacology, Vol. I: Schizophrenia research*. New York: Raven Press, pp. 169-178.
- Strauss, M. E., Brandt, J., and McSorley, P. 1986. Visual vigilance and psychopathology. (Letter to the Editors.) *Psychiatry Research*, 18, 285-287.
- Sullivan, H. S. 1940. *Conceptions of modern psychiatry*. New York: W. W. Norton and Company.
- Sullivan, H. S. 1944. The language of schizophrenia. In J. S. Kasanin (Ed.), *Language and thought in schizophrenia*. New York: W. W. Norton and Company.
- Sullivan, H. S. 1953. *The interpersonal theory of psychiatry*. New York: W. W. Norton and Company.
- Swets, J. A., and Kristofferson, A. B. 1970. Attention. In P. H. Mussen and M. R. Rosenzweig (Eds.), *Annual review of psychology*. Palo Alto, CA: Annual Reviews, pp. 339-366.
- Swets, J. A., and Sewall, S. T. 1963. Invariance of signal detectability over stages of practice and levels of motivation. *Journal of Experimental Psychology*, 66, 120-126.

- Sykes, D. H., Douglas, V. I., Weiss, G., and Minde, K. K. 1971. Attention in hyperactive children and the effect of methylphenidate (Ritalin). *Journal of Child Psychology and Psychiatry*, 12, 129-139.
- Tyrka, A. R., Cannon, T. D., Haslam, N., Mednick, S. A., Schulsinger, F., Schulsinger, H., and Parnas, J. 1995. The latent structure of schizotypy: I. Premorbid indicators of a taxon of individuals at risk for schizophrenia-spectrum disorders. *Journal of Abnormal Psychology*, 104, 173-183.
- Valone, K., Goldstein, M. J., and Norton, J. P. 1984. Parental expressed emotion and psychophysiological reactivity in an adolescent sample at risk for schizophrenia spectrum disorders. *Journal of Abnormal Psychology*, 93, 448-457.
- Valone, K., Norton, J. P., Goldstein, M. J., and Doane, J. A. 1983. Parental expressed emotion and affective style in an adolescent sample at risk for schizophrenia spectrum disorders. *Journal of Abnormal Psychology*, 92, 399-407.
- Van den Bosch, R. J. 1982. *Attentional correlates of schizophrenia and related disorders: In search for objective indicators of psychopathology*. Lisse, The Netherlands: Swets and Zeitlinger B.V.
- Venables, P. H. 1984. Cerebral mechanisms, autonomic responsiveness, and attention in schizophrenia. In W. D. Spaulding and J. K. Cole (Eds.), *Nebraska symposium on motivation, 1983: Theories of schizophrenia and psychosis*. Lincoln: University of Nebraska Press, pp. 47-91.
- Venables, P. H., Wilkins, S., Mitchell, D. A., Raine, A., and Bailes, K. 1990. A scale for the measurement of schizotypy. *Personality and Individual Differences*, 11, 481-495.
- Vibbert, M., and Bornstein, M. H. 1989. Specific associations between domains of mother-child interaction and toddler referential language and pretense play. *Infant Behavior and Development*, 12, 163-184.

- Vollema, M. G., and van den Bosch, R. J. 1995. The multidimensionality of schizotypy. *Schizophrenia Bulletin*, 21, 19-32.
- Wagener, D. K., Hogarty, G. E., Goldstein, M. J., Asarnow, R. F., and Browne, A. 1986. Information processing and communication deviance in schizophrenic patients and their mothers. *Psychiatry Research*, 18, 365-377.
- Wagner, M., Kurtz, G., and Engel, R. R. 1989. Normal P300 in acute schizophrenics during a Continuous Performance Test. *Biological Psychiatry*, 25, 788-792.
- Walden, T. A., and Baxter, A. 1989. The effect of context and age on social referencing. *Child Development*, 60, 1511-1518.
- Walden, T. A., and Ogan, T. 1988. The development of social referencing. *Child Development*, 59, 1230-1240.
- Walker, E. 1981. Attentional and neuromotor functions of schizophrenics, schizoaffectives, and patients with other affective disorders. *Archives of General Psychiatry*, 38, 1355-1358.
- Walker, E., and Green, M. 1982. Motor proficiency and attentional-task performance by psychotic patients. *Journal of Abnormal Psychology*, 91, 261-268.
- Walker, E., and Lewine, R. J. 1990. Prediction of adult-onset schizophrenia from childhood home movies of the patient. *American Journal of Psychiatry*, 147, 1052-1056.
- Walker, E., and Shaye, J. 1982. Familial schizophrenia: A predictor of neuromotor and attentional abnormalities in schizophrenia. *Archives of General Psychiatry*, 39, 1153-1156.
- Watt, N. F., Anthony, E. J., Wynne, L. C., and Rolf, J. E. (Eds.) 1984. *Children at risk for schizophrenia: A longitudinal perspective*. Cambridge: Cambridge University Press.

- Watters, D. A., Thomas, B. H., and Steiner, D. L. 1990. Factor analysis of the Nowicki-Strickland locus of control scale: Why is replication so difficult? *Educational and Psychological Measurement*, 50, 515-523.
- Ware, J. R., Kowal, B., and Baker, R. A. 1964. The role of experimenter attitude and contingent reinforcement in a display. *Human Factors*, 6, 111-115.
- Willett, J. B., and Sayer, A. G. 1994. Using covariance structure analysis to detect correlates and predictors of individual change over time. *Psychological Bulletin*, 116, 363-381.
- Wilson, J. S., and Costanzo, P. R. 1995. *A preliminary study of attachment, attention, and schizotypy in young adulthood*. Manuscript under review.
- Winters, L., Cornblatt, B., and Erlenmeyer-Kimling, L. 1991. The prediction of psychiatric disorders in late adolescence. In E. Walker (Ed.), *Schizophrenia: A life-course developmental perspective*. New York: Academic Press, pp. 123-137.
- Wohlberg, G. W., and Kornetsky C. 1973. Sustained attention in remitted schizophrenics. *Archives of General Psychiatry*, 28, 533-537.
- Wynne, L. C., Ryckoff, I. M., Day, J., and Hirsch, S. I. 1958. Pseudomutuality in the family relations of schizophrenics. *Psychiatry*, 21, 205-220.
- Wynne, L. C., and Singer, M. T. 1963a. Thought disorder and family relations of schizophrenics: I. A research strategy. *Archives of General Psychiatry*, 9, 191-198.
- Wynne, L. C., and Singer, M. T. 1963b. Thought disorder and family relations of schizophrenics: II. A classification of forms of thinking. *Archives of General Psychiatry*, 9, 191-198.
- Wynne, L. C., Toohey, M. L., and Doane, J. 1979. Family studies. In L. Bellak (Ed.), *The nature of schizophrenia: New approaches to research and treatment*. New York: Wiley.

- Zahn, T. P., Carpenter, W. T., and McGlashan, T. H. 1981a. Autonomic nervous system activity in acute schizophrenia: I. Method and comparison with normal controls. *Archives of General Psychiatry*, 38, 251-258.
- Zahn, T. P., Carpenter, W. T., and McGlashan, T. H. 1981a. Autonomic nervous system activity in acute schizophrenia: II. Relationships to short-term prognosis and clinical state. *Archives of General Psychiatry*, 38, 260-266.
- Zupin, J., and Spring, B. 1977. Vulnerability: A new view of schizophrenia. *Journal of Abnormal Psychology*, 86, 103-126.

BIOGRAPHY

I was born in Annapolis, Maryland, on November 21, 1958. I graduated from St. John's College in Annapolis, Maryland, in 1981, where I was awarded a Silver Metal for Senior with Highest Standing, First Prize Awards for Best Freshman and Best Sophomore Annual Papers, and an Honorable Mention for my junior paper. Thereafter I attended the University of Colorado at Boulder briefly, in a failed attempt to learn how to construct passive solar energy homes, an attempt that I aborted in part by reading too much Jung instead of completing calculus assignments. I attended the Naropa Institute in Boulder for a semester, taught kindergarten there and worked at a day care center in Spanish Harlem, New York, for a year. For seven years I worked as a legal assistant in securities litigation at Debevoise and Plimpton, a large New-York based law firm. This work took me to their Washington, D.C. office, and while there I completed a large number of courses in undergraduate psychology at the University of Maryland's College Park campus. I also had the opportunity to assist in the representation of a long-time patient at St. Elizabeth's Hospital, an experience that left a profound impression on me. I returned to graduate school at Duke in 1991, and while there have taught a number of courses, coordinated the student psychology clinic, and assisted with research on resilience in the Duke University Talent Identification Program. While at Duke I published, with Drs. Vicki B. Stocking and David Goldstein, a paper entitled "Gender differences in motivations for course selection: Academically talented students in an intensive summer program." Several other papers are currently under review. I was awarded a Sigma Xi Grant-in-Aid for Research and an American Psychology Association Science Directorate Dissertation Award for this dissertation project. I live in North Durham with my wife, Julie C. Dunsmore, Ph.D., who as a developmental psychologist investigates many of the same issues in normative development that concern this dissertation, and with our four cats, Barney, Henry, Dana, and Dinah.

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